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Astronomy®

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September 2002

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- The Artists of *Cosmos* Captured Unseen Worlds

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MEADE
LX200GPS
A NEW WORLD STANDARD
MEADE LX200GPS
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MEADE

Right-to-left: Meade 8", 10", and 12" LX200GPS Schmidt-Cassegrain telescopes. Manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

New 2002
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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

DPM Library

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment. The primary mirror lock-knob is located directly above the manual focus knob.

Revolutionary rear-cell systems that enable new levels of precision in focusing in all photo-visual applications and in image centering on CCD chips:

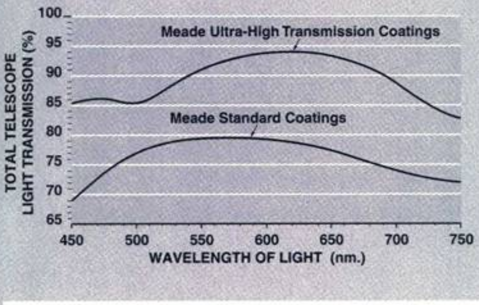
Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

The new Autostar II control system includes all of the features of previous LX200 models and in addition includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 145,000 celestial objects. A partial listing of Autostar II database libraries and numbers of objects:

New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28,484
SAO, Hipparcos, and Draper Star Catalogs	63,404
Large Bright Quasars Survey (LBQS)	1055
Messier (M) and Caldwell Catalogs	219
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645
Major planets from Mercury to Pluto	8

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by 20% over the visible spectrum. See graphs below.



SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5-Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 185-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 145,000-object onboard celestial software library; GPS alignment system with 16-channel GPS receiver, magnetic declination compensation, and true-level and North electronic sensors; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

MEADE LX200GPS SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20% *(see ad in June 2002 issue)*: 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 7" LX200GPS – $150.

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Drive speeds, each axis	185 speeds, from .01x sidereal to 8°/sec.	9 speeds, from 0.5x sidereal to 3°/sec.
Tracking rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	147,541 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01.

AUTHORIZED MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

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Orders & Information: 416-787-4581.

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Orders & Information: 416-783-4140.

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COVER PHOTO: NGC 4038/9 by European Southern Observatory

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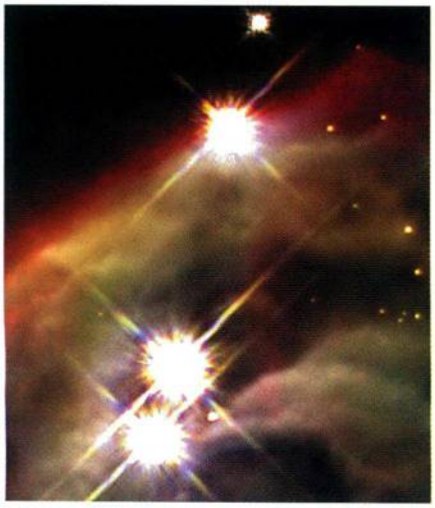

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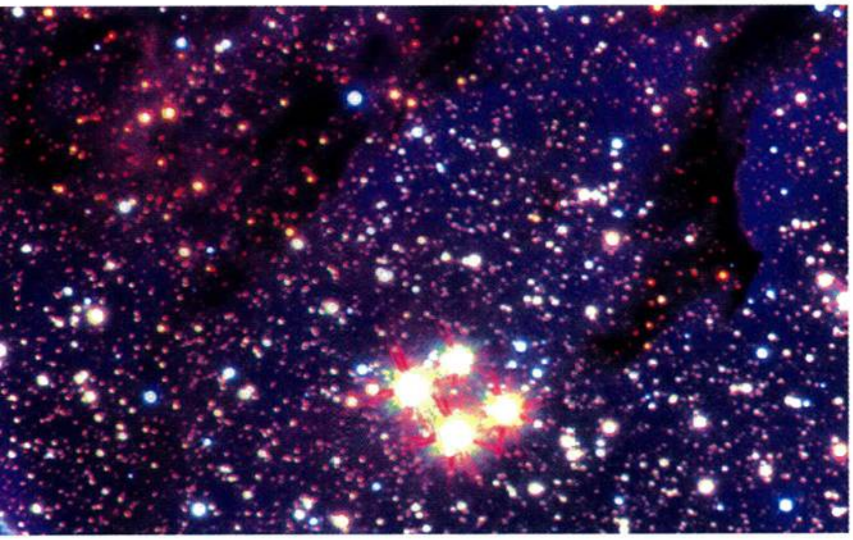

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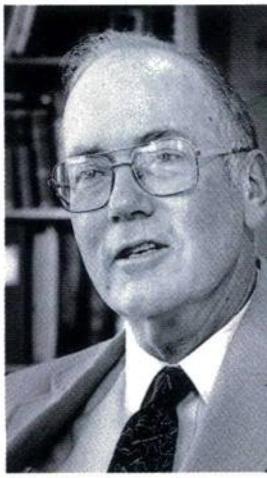

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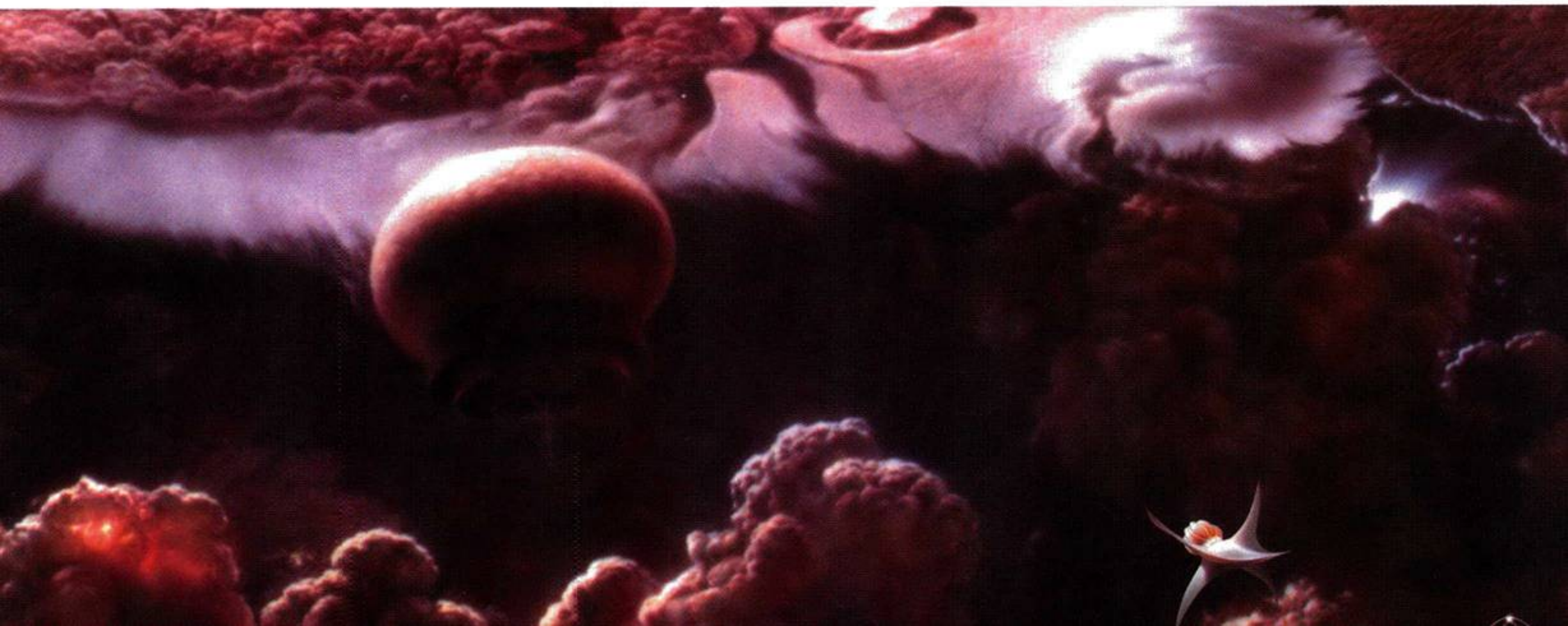

40 The Artists Behind the Wonder Adolf Schaller

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

What's in a Star Party?

I recently overheard some beginning astronomers ask where they could find help getting started, especially with selecting and using their first telescopes. We also regularly get letters from readers who make this same request.

We try to publish a good deal of material to help people select, set up, collimate, align, clean, and use telescopes, both online at Astronomy.com and in the magazine. But it's sometimes difficult to translate from the written word to action, especially considering how many styles of telescopes get manufactured these days. In fact, even Go-to scopes require some special knowledge. If you can't align your telescope with a given star, you can't use your machine.

I was reminded of another sort of question we get from readers: "What's a star party all about?" "Are beginners welcome?" And I realized that a valuable resource was going unused. I had just returned from the Riverside Telescope Makers Conference and Astronomy Expo (RTMC), among the biggest and oldest amateur astronomy gatherings in the country. It's an annual event held at Camp Oakes in Big Bear, California, over Memorial Day weekend. Manufacturers come and set up booths to display their equipment. Amateurs who build their own bring them to show and share.

Ralph J. Merletti

The main telescope field at RTMC draws people to check out and test equipment.

The camp is filled with tents and telescopes of every description, and as night falls, the Expo turns into a giant star party. After all, a star party is primarily a camp-out with telescopes where people gather to spend a night or more looking at the sky and comparing notes. At RTMC any visitor can try out telescopes provided by the manufacturers or roam the camp and ask to take a peek through an individual's telescope. Amateurs love to share their hobby.

RTMC offers a beginners' corner, where volunteers act as hosts and teachers. When I walked by the beginners' corner on Friday and Saturday, the hosts had no audience. Newcomers were missing a perfect opportunity to learn how to set up and use a telescope. And it's here you might find a mentor (and friend) for life.

But you can seek such help in places closer to home; star parties occur throughout the world. Most parties set aside a special area or program for beginners. Take advantage of this rich source of knowledge. You can learn a lot in a short time, meet people who will share opinions and ideas, and have some fun at the same time. Go to our "Looking Ahead" column on page 98, and visit our website at Astronomy.com for the latest news of star parties near you or near where you might take a vacation.

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LX90

MEADE

8" LX90

THE TELESCOPE OF A LIFETIME

MEADE
LX90
AUTOSTAR
MEADE

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability to any* object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is an instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; operating instructions. **$1695. Ultra-High Transmission Coatings group** increases image brightness by 20% (*see ad in June 2002 issue*): **add $175.** Packing & shipping in the 48 states: $95.

New 2002 Meade General Catalog!
Call, write or fax for your free copy.

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MEADE®

LXD55

Choose from eight models of Meade LXD55-Series Schmidt-Newtonians and Achromatic Refractors, each with Autostar® or Electronic Controller — from $579, *complete!*

Meade Autostar-equipped LXD55-Series telescopes permit a range of operations never before available on telescopes of their price class. Push the GO TO button and watch as the telescope fast-slews at 4.5°/second to any of *thousands* of galaxies, nebulae, and star clusters, from the brightest to the most obscure, placing each automatically and unerringly in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.

MEADE
LXD55
AUTOSTAR
MEADE
ENTER
MODE
GO TO

Shown: Meade Model SN-8 8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System

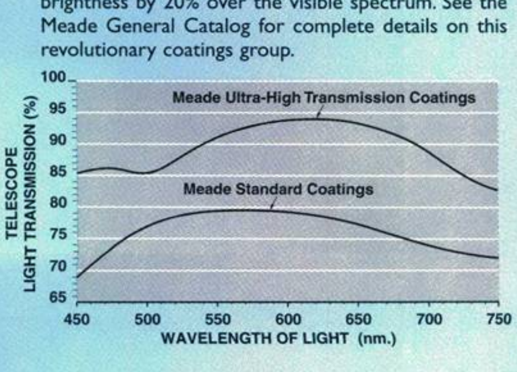
Meade LXD55 Schmidt-Newtonians open up the skies to images and capabilities previously unavailable in telescopes of their aperture and price level. Consider what a Meade LXD55 telescope can do for your observing program:

6" Model SN-6 — Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope moves effortlessly and automatically from major planet to asteroid to galaxy to nebula at 4.5°/second, placing every object in the center of the telescopic field. Study fine fault lines on the Moon, structural detail in Jupiter's cloud belts and Red Spot, the Cassini division in Saturn's rings, and much more.

8" Model SN-8 — With 78% more light-gathering power than the 6" model, the 8" SN-8 roughly triples the number of observable objects in deep-space and resolves extremely fine planetary detail as well: Jupiter's cloud belts are seen as a web of intricate discontinuities; transits and shadow transits of Jupiter's main satellites are observable; six of Saturn's satellites may be seen in revolution about the planet. Deep-space phenomena take on new character with the larger 8" aperture, as Autostar moves the telescope automatically from one spectacular object to the next. CCD images at the telescope's prime f/4 focus show a new level of resolution and detail after only a few minutes' exposure.

10" Model SN-10 — A quantum leap in image brightness and resolution, the 10" SN-10 provides for a lifetime of serious study in deep-space or within the Solar System. Use Autostar to take an automatic tour, on any given evening, of, say, the 200 brightest diffuse nebulae, spiral galaxies, and globular star clusters. Or, with Autostar's push-button electronic slow-motion controls, scan the surface of the Moon at high magnification. Let Autostar locate and center in the field the outer planets Uranus and Neptune, now visible as finite-sized orbs, or Pluto, at the telescope's very limit of observability. It is an uncommon observer who might outgrow the capabilities of the Meade 10" SN-10.

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by 20% over the visible spectrum. See the Meade General Catalog for complete details on this revolutionary coatings group.



6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

Meade American-made diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Fast f/4 (8", 10") or f/5 (6") optics present brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser resolution. The standard-equipment **Autostar Dual-Axis Control System** permits an amazing range of operations: *automatic GO TO capability* at 4.5°/second on both axes, simultaneously, to 30,223 database objects (including galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs; double and variable stars; eight major planets; asteroids; and comets) or to any object of known RA and Dec; *nine selectable slew and slow-motion speeds* from 1x sidereal to 4.5°/sec.; plus *automatic sidereal-rate tracking* in RA, and much more.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

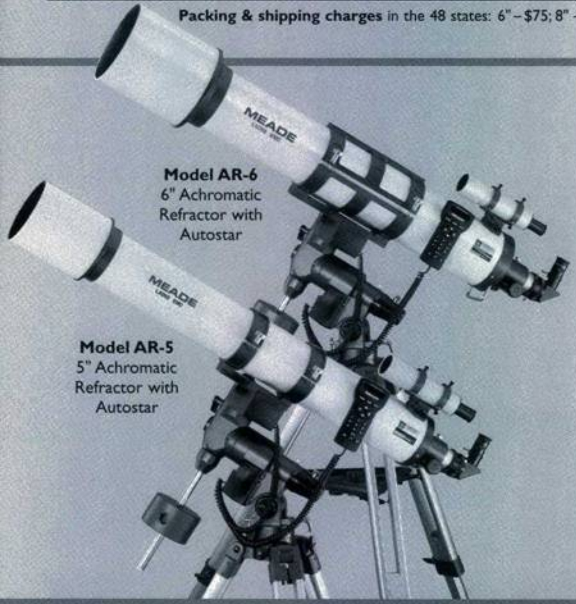
Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20%**:** 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.

Model SN-6
6" Schmidt-Newtonian with Autostar

Model SN-8
8" Schmidt-Newtonian with Autostar

Model SN-10
10" Schmidt-Newtonian with Autostar



Model AR-6
6" Achromatic Refractor with Autostar

Model AR-5
5" Achromatic Refractor with Autostar

5" and 6" LXD55-Series Achromatic Refractors with Autostar

With objective lenses that resolve to the theoretical limits for their apertures, Meade 5" and 6" LXD55 refractors present all of the diffraction-limited optical performance obtainable from the classical 2-element achromat design. Lunar, planetary, and deep-space images are rich in resolution and contrast, with a minimum of chromatic aberration. Both refractors allow for the full range of Autostar functions described above, including automatic dual-axis GO TO operation at 4.5°/second and nine selectable slew speeds from 1x sidereal to 4.5°/second, with the standard-equipment Autostar hand controller.

SPECIFICATIONS: Models AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 5" f/9 or 6" f/8 achromatic refractor optical tube assembly with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm achromatic viewfinder; all-metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

5" Model AR-5 Achromatic Refractor	**$695**
6" Model AR-6 Achromatic Refractor	**895**

Packing & shipping charges in the 48 states: 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; and 4.5°/second for rapid-slew of the telescope across the sky. ***#497 Autostar Controller may be added at any time in the future and, when plugged into the telescope's control panel, permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group increases image brightness by 20%**:** 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2002

Model SN-6EC
6" Schmidt-Newtonian with Electronic Controller

Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller

Model AR-5EC
5" Achromatic Refractor with Electronic Controller

MEADE®

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

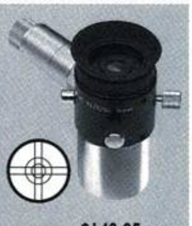
6.4, 9.7, 12.4, 15, 20, 26mm	each: **$79.95** (4.54)
32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA: 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000™
f/6.3 Focal Reducer/Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

***#929** or **#930**,* each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA: 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

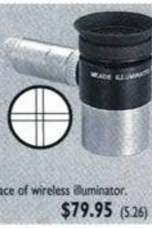
#908X–Threads into 1.25" eyepieces. 26mm dia.	**99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to less than one second. A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with *any* brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.

$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7: or for visual applications with 1.25" or 2" eyepieces.

249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)

15.00 (3.86)

#644

MEADE
FLIP-MIRROR SYSTEM

#647

MEADE
FLIP-MIRROR SYSTEM

ELECTRONIC CONTROLLER
MEADE

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk........ **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

CCD f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

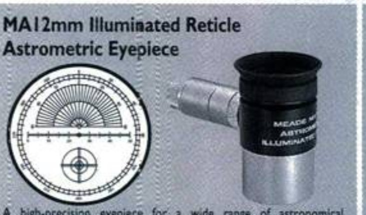
$34.95 (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

$49.95 (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:

99.95 (8.58)

#776 Case for ETX-105EC:

99.95 (8.58)

#775 for ETX-125EC:

149.95 (13.38)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70 .... **19.95**
#673 for ETX-90....... **24.95**
#675 for ETX-105...... **27.95**
#678 for ETX-125...... **29.95**

Pictor 216XT CCD Autoguider/Imager

The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotography.

$695. (12.00)

ETX® Deluxe Field Tripod

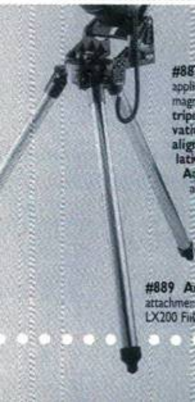
#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag (shown) with pocket for accessories.**

$199.95 (10.00)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)



Advanced Field Tripod for ETX-125

#887: Yields rock-solid stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:

$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:

$119.95 (6.85)

ELECTRONIC CONTROLLER
MEADE

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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MEADE

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909-626-2219

CALIFORNIA

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818-347-2270 or toll-free
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Fresno, CA 93710
559-432-0446

CALIFORNIA

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300 Lincoln Center, Stockton, CA 95207
209-477-5566

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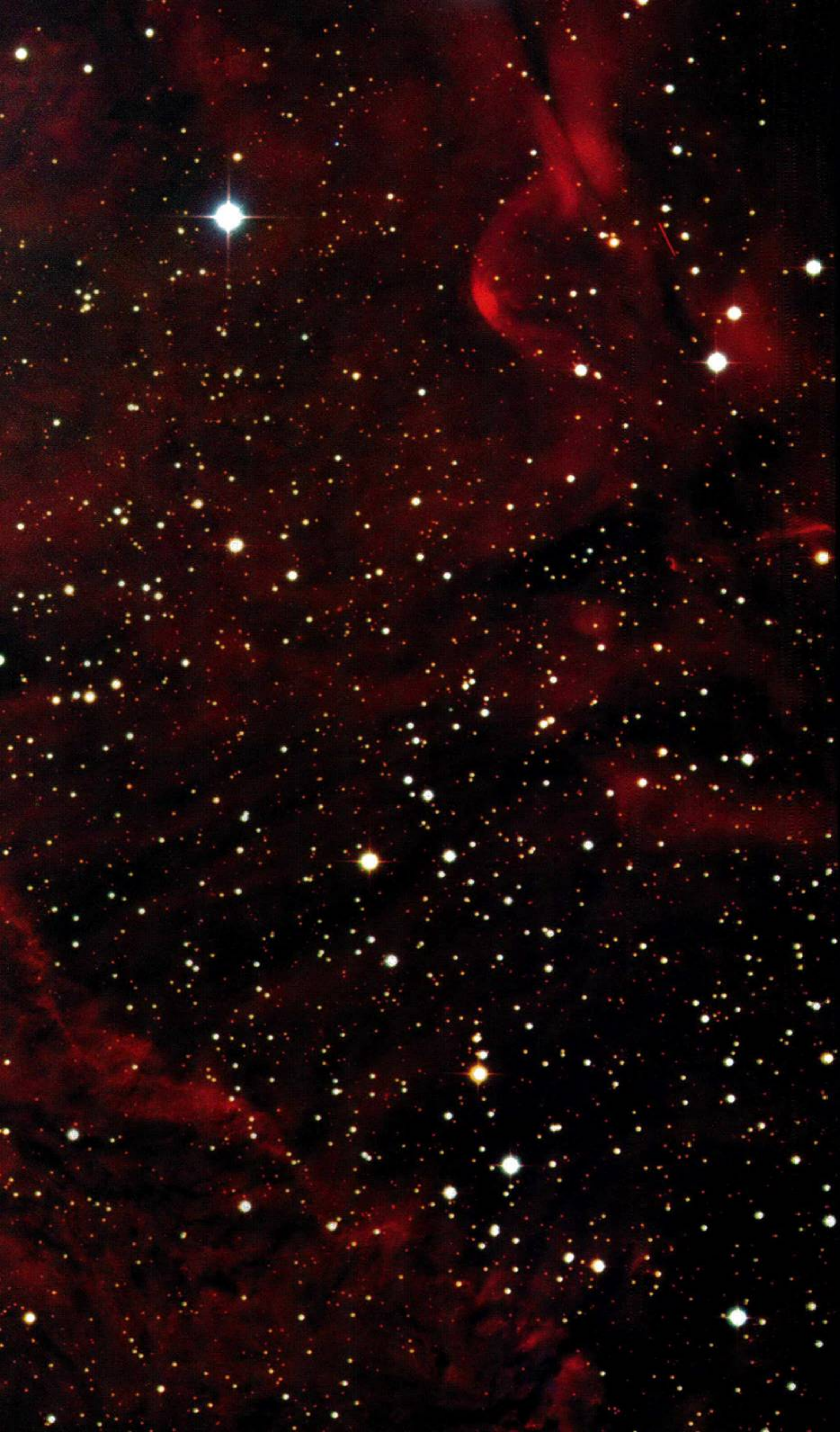

sky Gem

Dust Carves Hydrogen's Ruddy Glow

Dark, obscuring dust lanes wind through delicate tendrils of hydrogen gas in NGC 2264, a complex emission region surrounding the blue-white star S Monocerotis (top). Some dust patches have a bluish cast because the dust preferentially scatters that light — the same reason Earth's daytime sky looks blue.

© Anglo-Australian Observatory; photograph by David Malin

Fossil Fuels From Space?

As an amateur astronomer, but professional geologist, I must ask you to clarify the geological objections to the central tenet of the article "Mining for Cosmic Coal" by Sun Kwok (June 2002). The author suggests that recent astronomical observations lend support to the notion that Earth's fossil fuels derive from the period of planetary accretion, about 4.6 billion years ago. Kwok acknowledges that one such objection is that primordial hydrocarbons would not have survived the high temperatures involved in the accretion process. However, this understates the problem. First, hydrocarbons would not have survived the high temperatures involved in wholesale post-accretionary differentiation of the planet's core, mantle, and especially the crust. Second, fossil fuels overwhelmingly occur in relatively young rocks, whereas the primordial hydrocarbon hypothesis would predict that they should occur in rocks of all ages. Third, coal commonly contains fossils of the plants that geological hypotheses claim fossil fuels derived from. Furthermore, those fossils confirm that the coal containing them formed during relatively young geological time (less than 400 million years). I do not dispute the astronomical observations presented in the article, or their astronomical significance. However, it is a disservice to science, geological or astronomical, to present a one-sided view of a controversial and unsupported concept. — *Simon Hanmer, Ottawa, Ontario, Canada*

There is little doubt that much of the coal that is mined today is of biological origin. The question is, is there any primordial coal deep inside Earth? Post-accretion processing inside terrestrial planets, asteroids, and satellites might have destroyed most of the primordial organic solids inside these bodies, but even the survival of a tiny fraction would be enormous on the terrestrial scale. The detection of kerogen-like material in meteorites is the clearest indication that some of the extraterrestrial organic compounds survived the formation of the solar system.

Could planetary nebulae, like the Ring Nebula (M57), contain coal-like substances? Some scientists think so. Robert Gendler

The purpose of my article is not to pass judgment on the Gold hypothesis, but to point out that the recent astronomical discovery of large-scale production of coal-like organic compounds by stars may have present-day implications on our solar system. As more and more star-manufactured solid-state materials are identified in meteorites, the star-Earth connection will be the increasing focus of scientific study in the coming decades. — Sun Kwok, Department of Physics and Astronomy, University of Calgary

Precession question

In "Astronomy 101" (June 2002, page 73) you have a very clear explanation of precession and its consequences. However, the arrow in the upper-left graphic is pointing in the wrong direction. Earth's axis precesses in the retrograde (clockwise) direction, as shown in the lower-right graphic on the same page. (It's easier to get that graphic right, since there are obvious references in the stars.)

This is a very common mistake; I have also seen astronomy textbooks get the direction reversed. Precession happens to buck the prograde trend, perhaps in an effort to keep all of us on our toes. — *John Weiss, Department of Astrophysics and Planetary Science, University of Colorado-Boulder*

Scoping out Konus refractors

Thank you for John Shibley's article "Get the Scoop on Italian Scopes" (July 2002). The article was well written and contained some very good information on Konus telescopes.

I have been observing the skies with a Konus "Konuspace 102" refractor for the past year and a half. Although it has some of the minor problems that Shibley found with the Konus 120 and 150 refractors, I have enjoyed this scope very much. I have also had some problems with the equatorial mount that was supplied with the scope, but I was able to correct it with a Hargraves strut.

Overall, this has been an excellent telescope. I have had numerous compliments on the optics and viewing capability of this scope from people who are not in astronomy, as well as by my peers in the astronomical society to which I belong. — *Charles Flowers, Reno, Nevada*

The universe in a new light

As a subscriber, I always look forward to Bob Berman's monthly contributions. He has an amazing way with words and a great sense of humor, and I always learn from his columns. His comments in the May 2002 issue amazed me. He states that when trying to answer some of the universe's most puzzling questions, "The trouble is with the question, not the answer." In just a few paragraphs, he manages to direct readers to a new way of looking at the cosmos. His insight is unbelievable. While I haven't yet read any of his books, that will soon change. — *Tony West, Corona, California*

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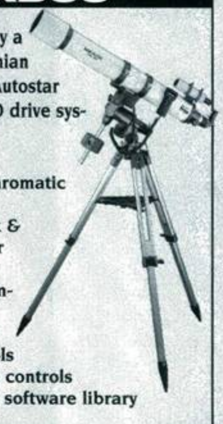

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EXTRASOLAR PLANETS

Opening the New-Planet Floodgates

▶ During the heady days of 1995 and '96, every announcement of a new exoplanet generated headlines around the world. Nowadays, it takes something special to attract attention. Two new exoplanets, announced on June 13 with 13 other planets, have done just that because they mark important milestones in the search for planets orbiting other stars.

One of the two has a mass only about 40 times that of Earth, making it the lightest planet yet found orbiting a solar-type star. The other is a 4-Jupiter-mass behemoth that orbits its star every 14 years or so, making it the first exoplanet found with a period longer than Jupiter's. "Those are the jewels in the bunch," says University of California, Berkeley, astronomer Debra Fischer, a member of the team that discovered the 15 new planets.

Not to be outdone, the European planet-hunting group led by Swiss astronomers Michel Mayor and Didier Queloz has chimed in with 12 new exoplanets, including one multiple-planet system. One of their new planets is also similar to Jupiter in mass and orbit. It orbits HD 190360a every 7.1 years, putting it at a distance of about 3.7 AU. "The key element is that it has a circular orbit, not an elliptical one. This reminds us strongly of our own solar system," says Queloz.

The 40-Earth-mass planet discovered by Fischer's team, which is led by Geoff Marcy at Berkeley and Paul Butler of the Carnegie Institution, whips around the star HD 49674 every 4.95 days. It belongs to a class of planets known as "hot Jupiters." But with a mass only 12 percent that of Jupiter, this planet is much closer to Uranus and Neptune in mass. "We've found all the hot Jupiters. The only planets we'll be finding from now on will be substantially lower in mass, or more massive ones farther away. The hot Jupiters are picked," says Fischer, who adds that only about 0.8 percent of solar-type stars have hot Jupiters.

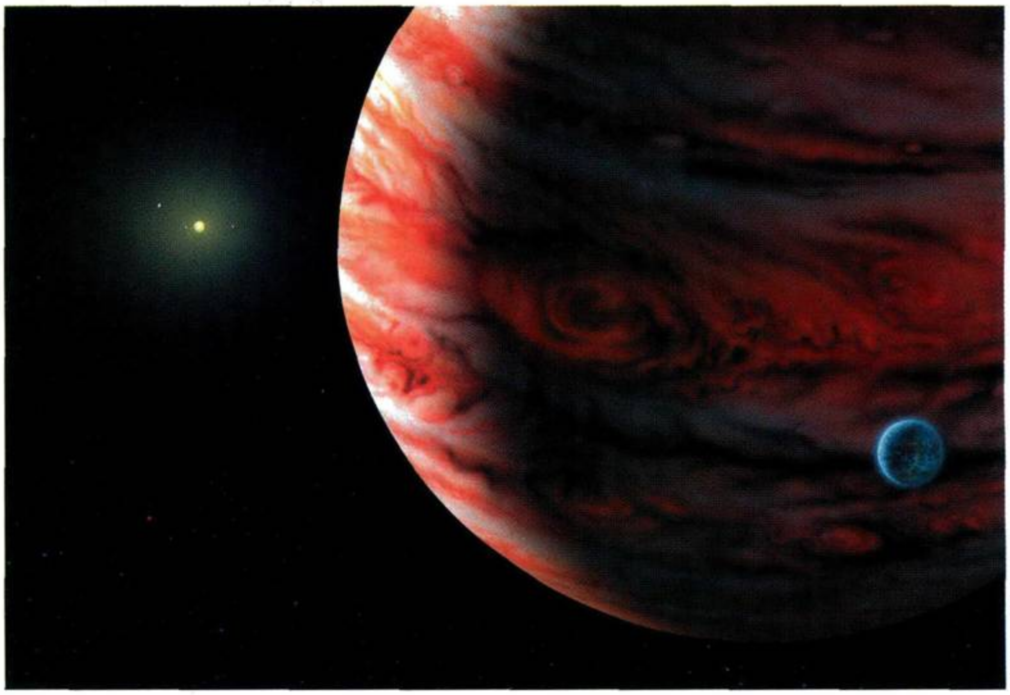
The discovery demonstrates that the method used by the Marcy/Butler team is now sensitive enough to detect planets with masses as low as Uranus and Neptune. The team discovers planets by detecting subtle wobbles in the motions of stars induced by the gravity of orbiting planets.

While the team can discover hot Jupiters in a few days given the planets' short orbital periods, the discovery of the planet with a 14-year orbital period is a testament to patience. Marcy and his colleagues had strong evidence of this planet for several years, but waited until now to report the planet because they wanted to observe its host star through nearly an entire orbit.

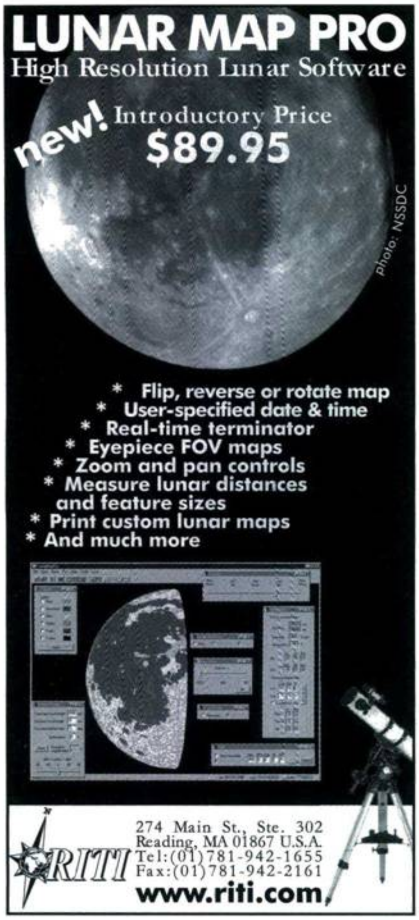
This newly discovered planet orbits 55 Cancri, a star already know to possess an inner planet with a 14.6-day period. The team also announced a third planet around 55 Cancri, which orbits the star every 44.3 days. Not including the sun, only one other solar-type star is known to possess at least three planets.

Because the HD 190360a system does not have any inner jovian-mass planets, that system is much more likely than 55 Cancri to harbor terrestrial planets in the star's habitable zone.

"When Paul and I started the search 15 years ago, we thought we'd have to wait 13 years to find the first Jupiter," says Marcy. "So this 55 Cancri planet is a culmination of the type of patience that we always thought we would have to have. It's been luck that nature has provided Jupiters closer in, to tantalize us over the last six years. The added spice here is that we finally know that Jupiters exist out at 5 AU."


NASA/Lynette Cook

In this artist's concept, a moon circles the Jupiter-mass planet that orbits far from 55 Cancri.



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Most of the other new exoplanets are fairly similar to the majority of known exoplanets. They orbit their stars between 0.5 and 3 astronomical units and have masses between 0.75 and 3 times that of Jupiter. "Most of the planets we have found orbit well beyond the Earth-sun distance," says Marcy. "The masses are modest, about the mean mass of Jupiter. It suggests that our own Jupiter may be a typical giant planet."

With these discoveries, the number of known exoplanets exceeds 100, although the exact total remains uncertain because some objects are borderline between planets and brown dwarfs, and a few of the announced planets might not survive further scrutiny.

— Robert Naeye

COSMOLOGY

Ripples Bolster Cosmic Inflation

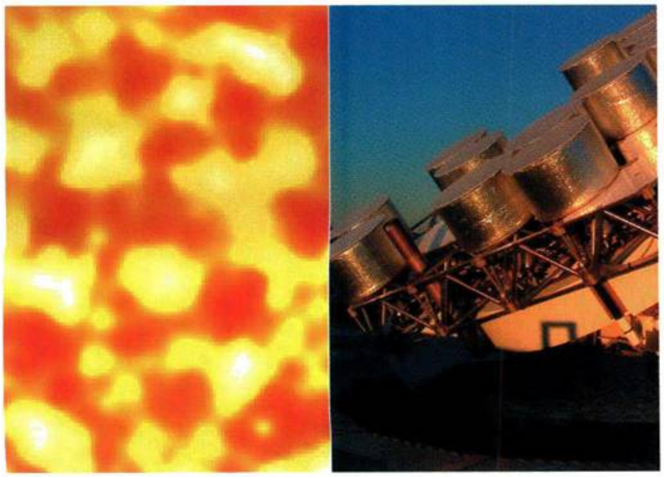
▶ According to the Book of Genesis, the Lord said "Let there be light" on the first day. The universe waited some 300,000 years after the Big Bang to reach the same state. That's when it had cooled enough for electrons to combine with protons and form neutral hydrogen atoms. Photons were then no longer shackled by free electrons and could roam the universe unfettered.

Some 14 billion years later, the expansion of the universe has cooled this ubiquitous radiation to 2.73° Celsius above absolute zero. Now two research teams have just completed the most detailed study yet of this relic radiation.

The observations show tiny variations in temperature — as small as one part in 10,000 — which mark the density fluctuations that ultimately grew into the galaxy clusters of today. The observations also support the ideas that the universe experienced a violent period of inflation before it was even a second old, dark matter dominates ordinary matter, and the expansion of the cosmos is accelerating thanks to a mysterious force dubbed dark energy.

"We have seen, for the first time, the seeds that gave rise to clusters of galaxies," says Anthony Readhead of Caltech, who led one of the research teams. "These unique, high-resolution observations provide new and independent evidence that the universe is flat and is dominated by dark matter and dark energy."

Variations in the temperature of the cosmic background (left) seen with the Cosmic Background Imager (right) show the seeds of later galaxy clusters. CBI/Caltech/NSF



Readhead's team used an array of 13 microwave antennas, each about three feet in diameter, known as the Cosmic Background Imager (CBI). CBI sits on a remote plateau in the Atacama Desert of Chile at an altitude of 16,700 feet (5,080 meters). The other team, with researchers from England and Spain, used a radio telescope known as the Very Small Array (VSA). It consists of 14 antennas, each just six inches across. The VSA operates at an altitude of 7,290 feet (2,400 meters) on Mount Teide on Tenerife in the Canary Islands.

The Cosmic Background Explorer (COBE) satellite first studied the background radiation in detail more than 10 years ago. Although it provided ironclad proof for the Big Bang origin of the universe, it lacked the sensitivity needed to detect the temperature variations caused by quantum fluctuations in the early expansion.

In the past few years, several experiments have refined those measurements. The balloon-borne BOOMERANG and MAXIMA experiments, along with DASI at the South Pole, verified a key

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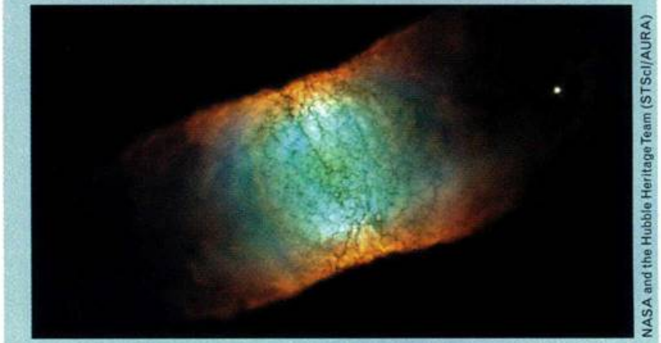

NASA and the Hubble Heritage Team (STScI/AURA)

DARK DUST LANES CRISSCROSS the planetary nebula IC 4406 in Lupus. These dust lanes, each about 160 astronomical units (15 billion miles) wide, lie at the boundary between the hot gas that produces the visible light seen in this Hubble image and neutral gas found by radio telescopes. The dust appears to be a thousand times denser than the rest of the nebula. IC 4406 represents the final stage in the life of a sunlike star. The star's outer layers were puffed off when it was a red giant, and that gas now glows from the ultraviolet radiation emitted by the white dwarf remnant. The nebula's gas and dust forms a vast donut that streams away from the dying star. We see the donut from the side, which nicely shows the lattice of dust lanes. In planetaries like the Ring Nebula (M57), we see the donut from above.

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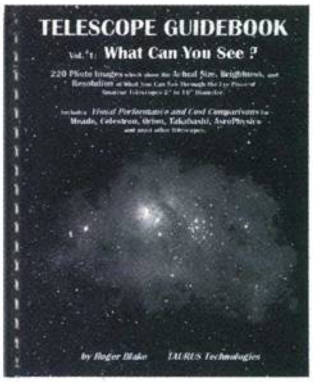

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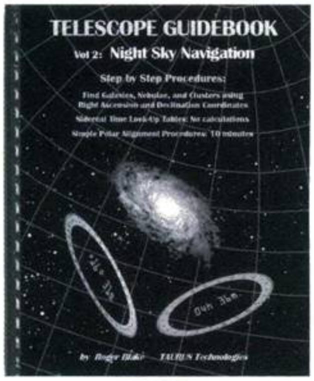

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prediction of inflation: the geometry of the universe is flat. And their measurements of other cosmological parameters further bolstered inflation.

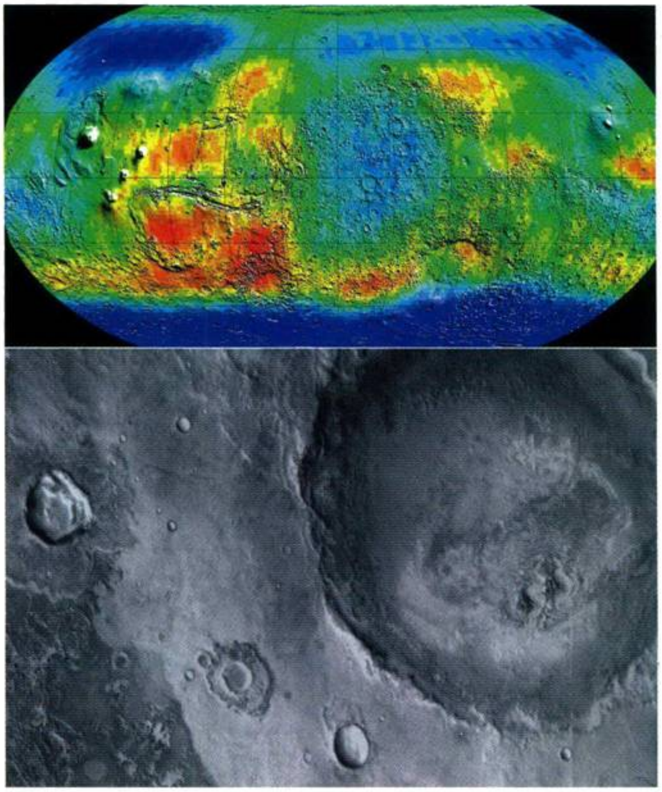
Now CBI and VSA have weighed in, and both confirm the flatness of the universe. In addition, they show that dark matter must make up a large majority of the universe's mass. This matter must be unlike the normal matter of our everyday existence, perhaps some exotic subatomic particle. The results also support the idea that the expansion rate of the universe is speeding up. This acceleration — first discovered in observations of distant supernovae — seems to be caused by a dark energy that opposes gravity.

The new studies join with previous experiments to form an even stronger case than a single experiment alone ever could. "Each new image of the early universe refines our model of how it all began," says Rita Colwell, director of the National Science Foundation, which helped fund the CBI observations. "This is basic research at its finest and most exciting."
— Richard Talcott

2001 MARS ODYSSEY

Mars: Wet and Layered

▶ "Water, water, everywhere, nor any drop to drink." While Coleridge's Ancient Mariner couldn't slake his thirst, future astronauts to Mars may have better luck. The latest results from the 2001 Mars Odyssey spacecraft show that huge quantities of water ice — enough to fill Lake Michigan twice over — lurk just below the planet's surface. And that may be just the tip of the iceberg.



A map of neutrons on Mars (top) shows the ice-rich regions near the south pole as deep blue. An infrared image of Terra Meridiani (above) shows signs of extensive layering. Top: NASA/JPL/University of Arizona/Los Alamos National Laboratory; above: NASA/JPL/Arizona State University

"This is really amazing," says William Boynton of the University of Arizona, Principal Investigator of Odyssey's Gamma Ray Spectrometer. "We were hopeful that we could find evidence of ice, but what we found is much more ice than we ever expected."

Planetary scientists located the ice in the top three feet (one meter) of soil in a large region around Mars's south pole. The Gamma Ray Spectrometer, a suite of three instruments designed to study both gamma rays and neutrons, actually detects hydrogen based on the intensity of gamma rays emitted by the element and the intensity of neutrons affected by it.

The observations reveal that 20 to 50 percent of the mass in this subsurface layer is in the form of water ice. Because rock has a significantly greater density than ice, it means that more than half the volume consists of ice. If future astronauts fill a bucket with this ice-rich polar soil and heat it, they'll end up with a bucket more than half full of water.

"The signature of buried hydrogen seen in the south polar area is also seen in the north," says William Feldman of Los Alamos National Laboratory, Principal Investigator for the neutron spectrometer, "but not in the areas close to the pole." That's because frozen carbon dioxide — dry ice — covers those areas during winter. Feldman expects to see more hydrogen in the north as spring approaches.

These hydrogen-rich polar regions coincide with areas known to be frigid and where ice should be stable — a key factor in the scientists' belief that the hydrogen traces water ice. The ice-rich layer lies about two feet (60 cm) beneath the surface at 60° south latitude and comes within one foot (30 cm) of the surface at 75° south latitude.

In other Odyssey news, infrared images from the spacecraft's THEMIS (Thermal Emission Imaging System) instrument indicate that Mars has experienced a series of environmental changes during previous active geological periods. "We knew from Mars Global Surveyor that Mars was layered, but these data are the first direct evidence that the physical properties of the layers are different," says Philip Christensen of Arizona State University, THEMIS's Principal Investigator. "The history of Mars is staring us in the face in these different layers, and we're still trying to figure it all out."

Planetary scientists targeted a layered region known as Terra Meridiani and created a mosaic from four daytime infrared images. The region shows a complex geology of craters and eroded surfaces, exposing at least four distinct rock layers in the temperature map. "Mars has exceeded our expectations," adds Christensen. "It would have been possible for the rocks to be very similar and thus give us all the same temperatures, but Mars has a more interesting story to tell." — R. T.

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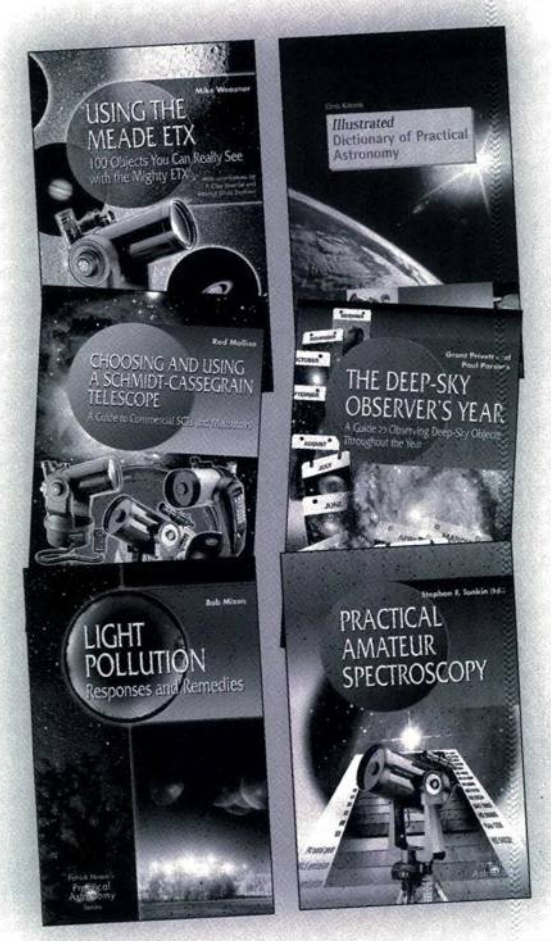
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GALACTIC CENTER

Starburst Ahead for Milky Way

Sometime in the next 300 million years or so, the center of our galaxy will come alive, gleaming with the light of thousands of new stars and spraying two long jets of material toward the galactic poles.

Astronomers from the Harvard-Smithsonian Center for Astrophysics (CfA) told the Milky Way's fortune at June's meeting of the American Astronomical Society in Albuquerque, New Mexico. Using the 67-inch (1.7-meter) Antarctic Submillimeter Telescope and Remote Observatory (AST/RO), the group learned that molecular clouds at the galaxy's nucleus are on the verge of collapse. When this happens, the event will trigger a burst of star formation and feed the black hole residing there.

"Many of the stars that form will be very massive and short-lived; they'll quickly use up their fuel and explode as supernovae," reports Antony Stark, who headed the research team with CfA colleague Chris Martin. We typically witness one supernova per century, but during this imminent active stage our descendants will see about one every year, Stark says.

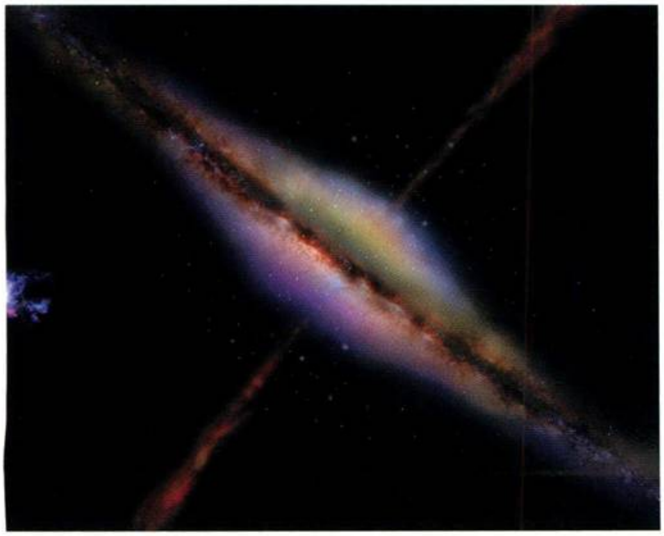
The upcoming event is the next step in a 500-million-year cycle of creation at the heart of the Milky Way Galaxy. When the cold molecular clouds at the galaxy's core reach a critical density, stars will form 10 to 100 times faster than the current rate. At the same time, infalling material will get gobbled by the Milky Way's central black hole while some is ejected in two long jets perpendicular to the galaxy's disk. After things settle down, gas will begin to collect again near the galaxy's center and then coagulate into clouds millions of times more massive than the sun. Once the clouds reach that critical density, they will set off another episode of starbirth.

"Most of the matter in these molecular clouds is very cold, at temperatures just a few tens of degrees above absolute zero," explains Martin. "At those low temperatures, gas emits submillimeter radiation rather than visible light."

AST/RO observed submillimeter emissions from carbon monoxide molecules in gas clouds at the center of the galaxy to learn the temperature and density of these clouds. Located at the South Pole, AST/RO takes advantage of the region's dry, cold air to observe this radiation, which usually gets absorbed by water vapor at other observing locations. According to the team, the results map the galaxy's center in unparalleled detail.

"We can combine our map with the recent x-ray map of the galactic center taken by NASA's Chandra X-ray Observatory as well as with observations at other wavelengths of light," Martin says. "Together, the data allow us to build a complete picture of the environment near the center of our galaxy." — VANESSA THOMAS

An artist depicts jets shooting from the Milky Way's center during its next starburst in about 300 million years. David Aguilar (CfA)



GAMMA-RAY BURSTS

Clinching the Supernova Link

Roughly once a day, a burst of gamma rays washes over the solar system. Although relatively weak by the time they reach us, these bursts lie so far away that — for a few seconds at least — they must be the brightest objects in the universe.

Learning what powers these events has been one of the top mysteries facing astrophysicists. Now, in at least one case, a smoking gun has been found: a massive star that had just gone supernova.

A faint supernova (arrow) marks the spot of a gamma-ray burst. Shri Kulkarni, Joshua Bloom, Paul Price, and the Caltech-NRAO GRB Collaboration

Two teams of researchers, one led by Shri Kulkarni of Caltech and the other by Kris Stanek of the CfA and Peter Garnavich of Notre Dame, turned an array of telescopes on a gamma-ray burst discovered on November 21, 2001. Once the burst's optical afterglow had faded, the astronomers measured the host galaxy's distance at *only* 5 or 6 billion light-years — so close that the researchers decided to search for a faint supernova. A week later, they were rewarded with the telltale light from an exploding star as well as a cocoon of gas fed by the progenitor star's stellar wind.

"With these observations we have tied this gamma-ray burst to an exploding star," says Kulkarni. He cautions, however, that the mystery may not be solved completely. First, supernovae have not been seen clearly in similar bursts. And second, many astronomers are convinced that other mechanisms, such as merging neutron stars, should also cause bursts. — R. T.

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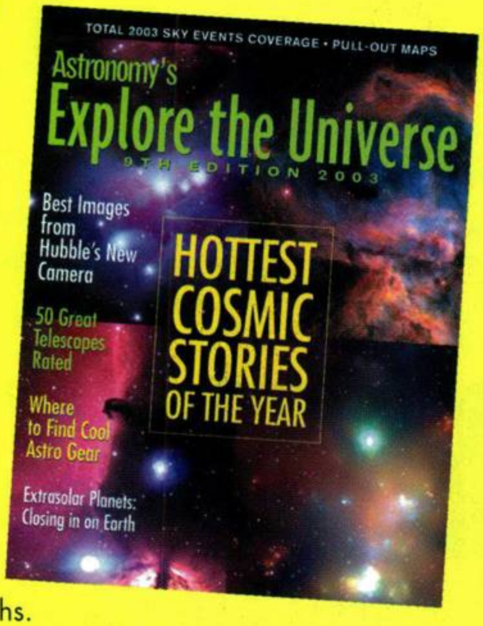

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The Ice Age Returns

Hubble's NICMOS camera is once again exploring the cool backwaters of the universe.

by Richard Talcott

Like a bad character in a grade B horror flick, the Hubble Space Telescope's prime infrared instrument has awakened from the dead. Yet unlike typical movie zombies, who tend to have multiple physical and personality problems, the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) seems none the worse for wear. In fact, as the images on the next three pages attest, NICMOS appears to be better than new.

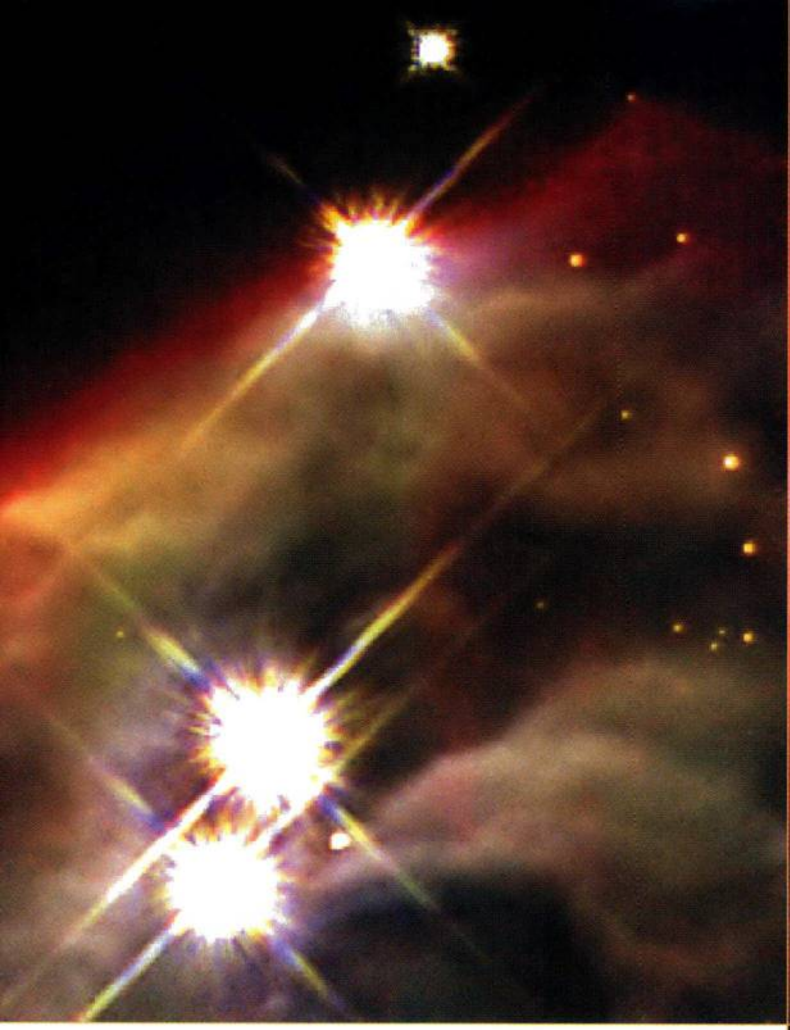
Astronomers released the first images from the revived instrument at the June meeting of the American Astronomical Society held in Albuquerque, New Mexico. One image should look vaguely familiar: The Cone Nebula in Monoceros (opposite) was also among the first targets for the new Advanced Camera for Surveys (see "Hubble's Grand New Vistas," August 2002). Viewing at near-infrared wavelengths, NICMOS peeled away the Cone's outer dust layers to reveal a dense inner region rippling with star formation.

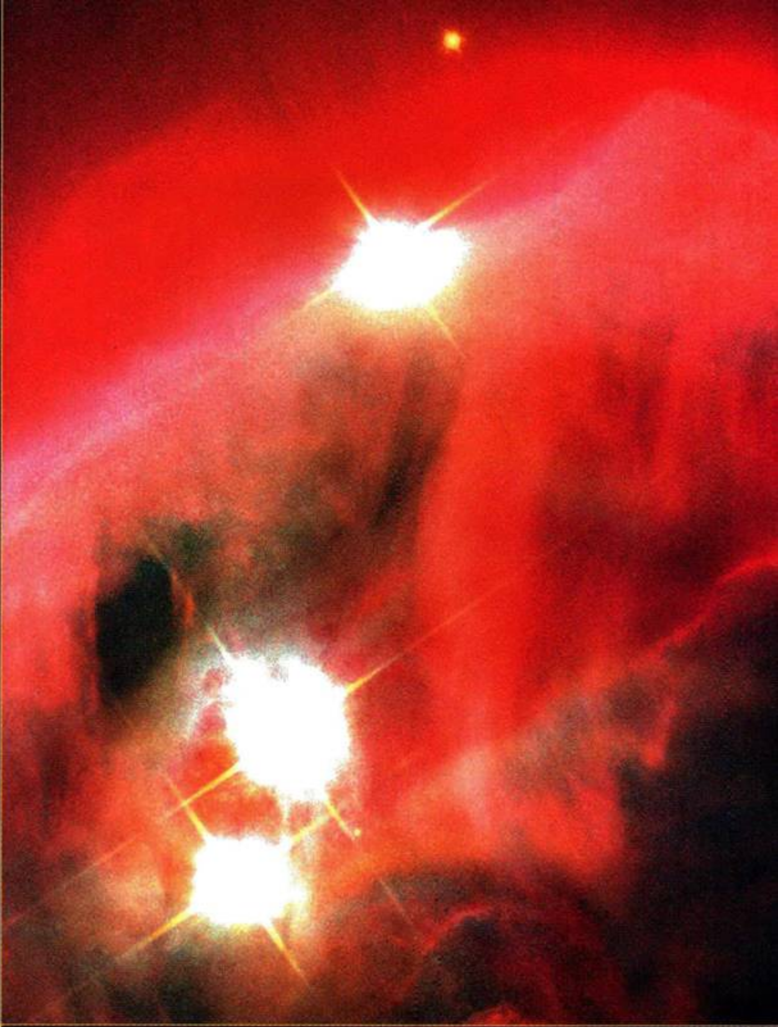
NICMOS peered beyond the Milky Way to capture its other two portraits (pages 32 and 33). The camera's vision penetrated the thick dust lane of the edge-on spiral galaxy NGC 4013 in Ursa Major and reached all the way to the core. There it found an apparent ring of stars encircling the galaxy's nucleus. The final photo shows a distant, ultraluminous infrared galaxy known as IRAS 19297–0406 in Aquila. Combining observations made with NICMOS and the Advanced Camera for Surveys, the image unveils a burst of star formation taking place as four galaxies slam into one another.

"It's fantastic that we have restored Hubble's infrared eyesight," says Rodger Thompson of the University of Arizona, Principal Investigator for the NICMOS instrument. "NICMOS has taken us to the very fringes of the universe and to a time when the first galaxies were formed. We can't wait to get back out there."

NICMOS returned to life shortly after NASA completed its fourth servicing mission to Hubble in March. Originally installed in February 1997, NICMOS used its infrared vision to probe the cool, dark regions of space. But the infrared detectors could work only if they were kept frigid. NICMOS was encased in frozen nitrogen at a temperature of –351° Fahrenheit (–213° Celsius). A small heat leak caused the nitrogen ice to evaporate about twice as fast as expected, and by January 1999 it was gone.

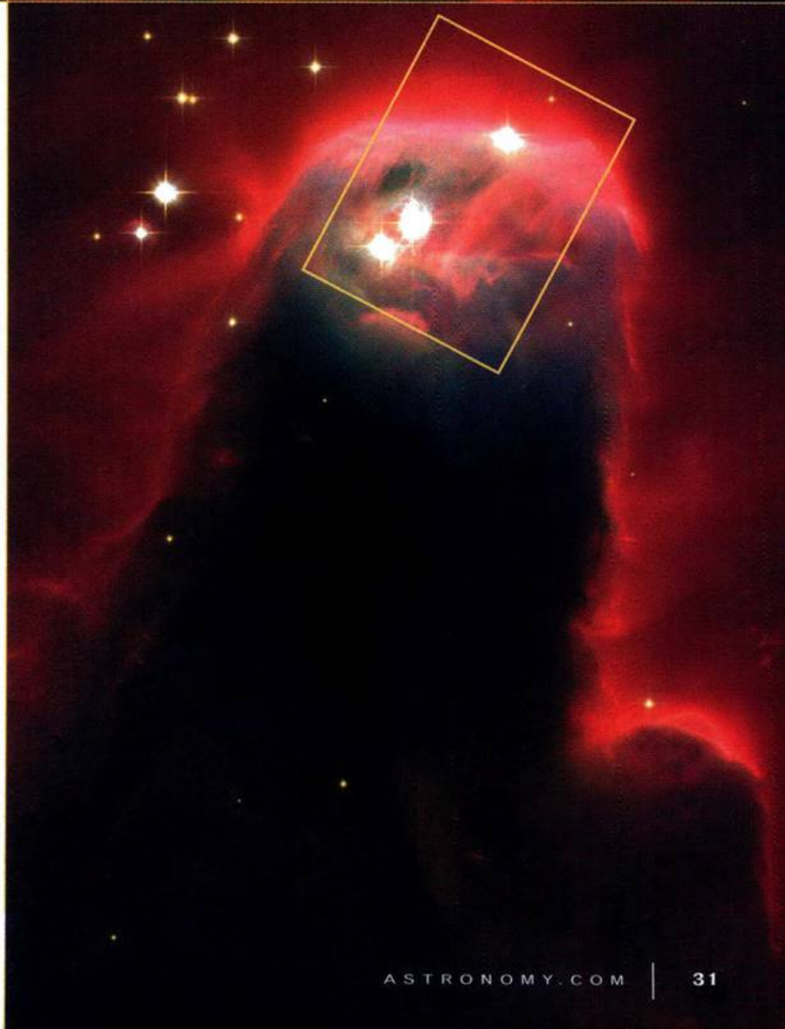
NASA engineers devised an experimental cryogenic system to reawaken NICMOS. The mechanical system works on principles similar to a home refrigerator, pumping ultra-cold neon gas through the internal plumbing of the instrument. At its core are three miniature, high-tech turbines that can spin as fast as 430,000 rpm. Ground controllers can adjust the speed of the turbines to change the temperature, and have now set the system at its optimal temperature of





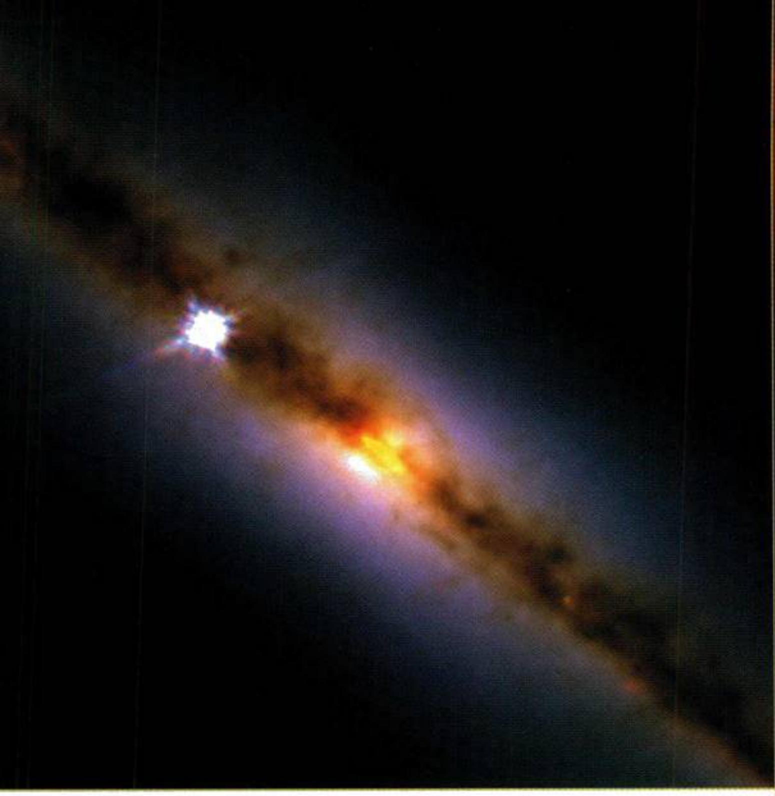
–321° F (–196° C). The new cooling system also produces little vibration, which would degrade the superior image quality of Hubble in the same way that a shaky telescope mount produces blurry images.

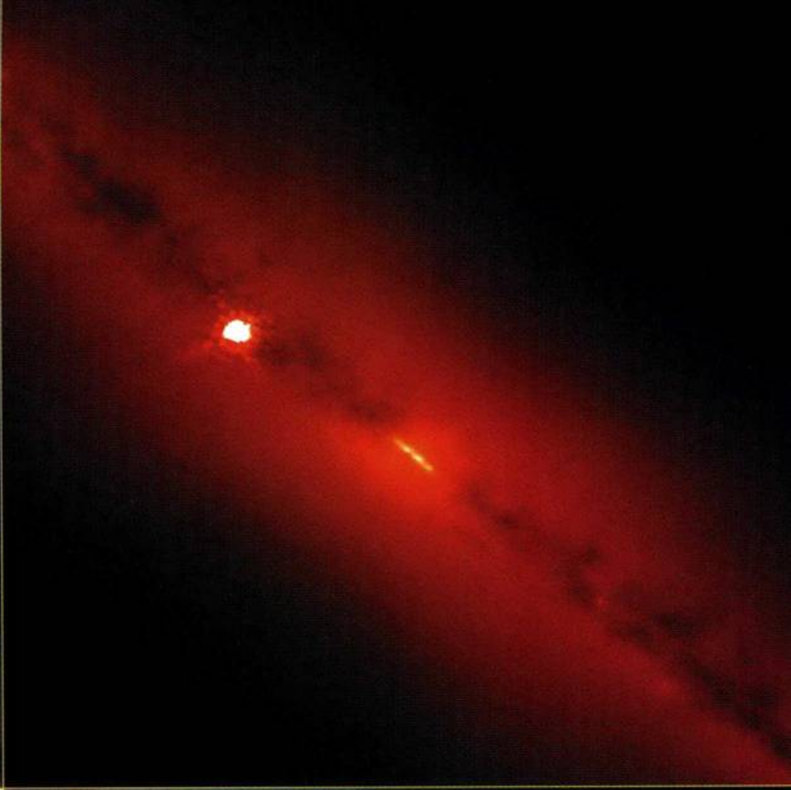
With NICMOS and the Advanced Camera operating perfectly, Hubble returns to its place as the foremost astronomical observatory. "The Hubble servicing mission has now been demonstrated to be a complete success," says Ed Cheng of NASA's Goddard Space Flight Center, Hubble Development Project Scientist. The beneficiaries will be astronomers seeking to understand a still-mysterious universe, but anyone with an eye for beauty can't help but get caught up in the quest. **A**

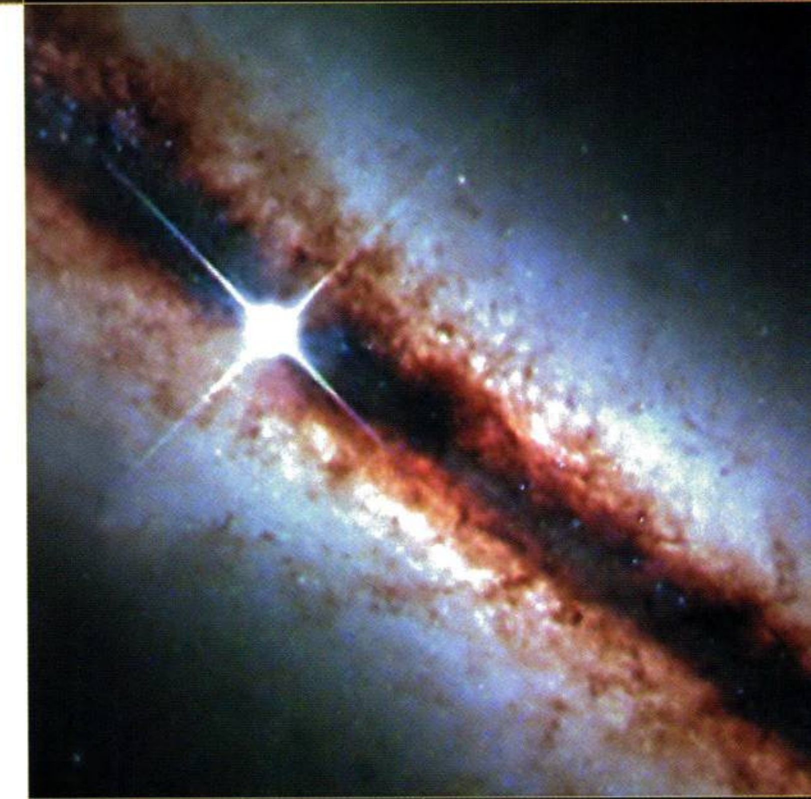


The NICMOS camera does many things well, but it excels at penetrating thick layers of dust. Yet even it has a difficult time piercing the dense dust layers that shroud the central regions of the Cone Nebula in Monoceros (above), which lies 2,500 light-years from Earth. NICMOS unmasked several stars (the yellow dots at upper right) that lie deep inside the nebula or perhaps behind it. Those stars don't appear in a visible-light image made with Hubble's Advanced Camera for Surveys (top right). (The four brightest stars lie in front of the nebula.) The images show just a half-light-year-wide portion at the tip of the Cone (right).

All NICMOS images: NASA, the NICMOS Group (STScI, ESA), and the NICMOS Science Team (University of Arizona); all ACS images: NASA, ESA, H. Ford (JHU), G. Illingworth (UCSC/LO), M. Clampin (STScI), G. Hartig (STScI), and the ACS Science Team

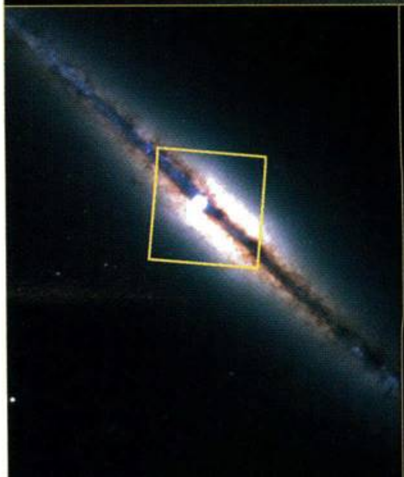




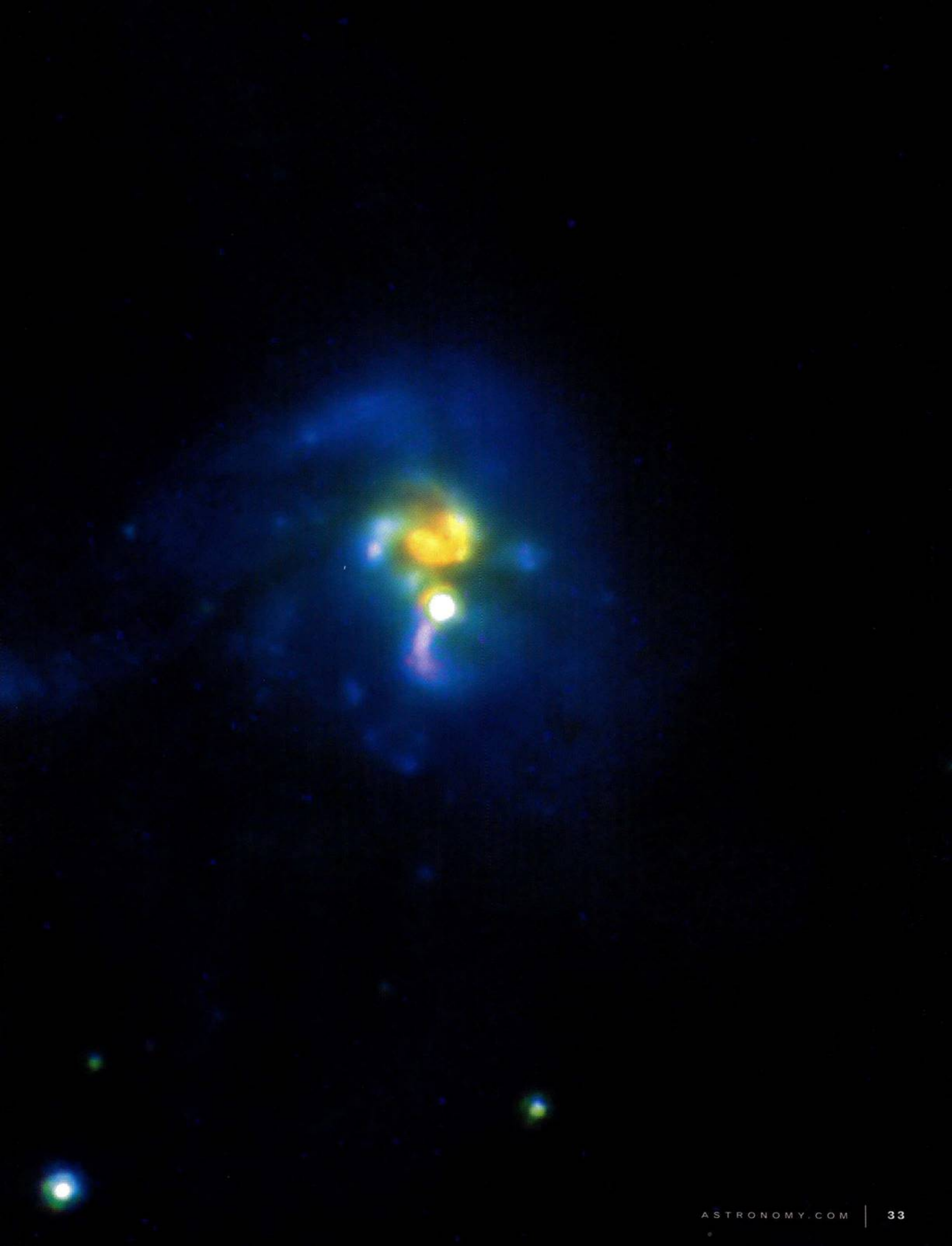


The gaze of NICMOS bores into the heart of the edge-on spiral NGC 4013, revealing what seems to be a golden ring of newborn stars centered on the galaxy's core (above). The ring spans about 720 light-years and churns out stars at a prodigious rate. Because the human eye cannot see in the infrared, astronomers assigned colors to the light passing through three different filters, with blue representing shorter wavelengths and red longer ones. The view through a single filter sensitive to emission from hydrogen gas shows the ring in greater detail (top right). A visible-light image (right), taken with Hubble's Wide Field and Planetary Camera 2, reveals no trace of the ring buried inside the 500-light-year-thick dust band. A ground-based view of the galaxy (bottom), which lies 55 million light-years away in Ursa Major, shows the region observed by Hubble.

WFPC2 image: NASA, the Hubble Heritage Team (STScI/AURA), and ESA; ground-based image: C. Howk (Johns Hopkins University), B. Savage (University of Wisconsin), N. A. Sharp (NOAO)/WIYN/NOAO/NSF



A massive collision in the distant universe makes a fitting target for the combined power of NICMOS and the Advanced Camera for Surveys. IRAS 19297–0406 (far right) radiates large amounts of visible, infrared, and ultraviolet light, a direct result of the fireworks that ensue when four galaxies collide. Astronomers expect the four galaxies to merge eventually into a single giant elliptical. For now, IRAS 19297–0406 blazes 100 times brighter in the infrared than the Milky Way thanks to a huge amount of warm dust generated as the system churns out stars at 100 times the rate of our own galaxy. The bright blue material surrounding the central region corresponds to ultraviolet light emanating from *the new stars. IRAS* 19297–0406 lies about 1 billion light-years from Earth in the constellation Aquila.



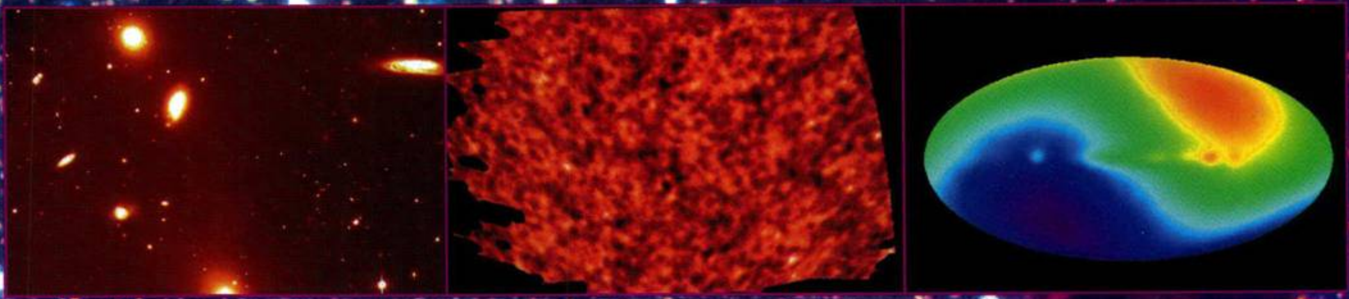
Beyond Cosmos

More than twenty years after the release of Carl Sagan's revolutionary series, the cosmos is a very different place.

by David J. Eicher

He arrived like an alien visitor from the world of academia sent straight into our living rooms. Comfortable, stylish, and perched on a rock awash with California waves, he calmly, clearly told us the ocean behind him amounted to nothing compared with the nearly infinite ocean of space he would take us through over the coming nights. It was the evening of September 28, 1980, and Carl Sagan, astronomy professor from Cornell, had begun to change science forever. Not only did he show us that scientists could be cool, but he delivered an intellectually meaningful tour of the history of astronomy, a status report on astronomical research and space exploration to 1980, and a reflection on civilization's progress on Earth and the probabilities of extraterrestrial life. In 13 episodes of *Cosmos*, which ranked as the highest-rated PBS show ever (until it was eclipsed in 1990 by Ken Burns's *The Civil War*), Sagan established the baseline of popular

The Pillars of Creation at the heart of the Eagle Nebula. European Southern Observatory



Many astronomical discoveries have followed in the twenty-plus years since the making of *Cosmos*. From left to right: Superclustering of galaxies, ACO 3341. ESO; **A view of the early universe at 300,000 years old.** BOOMERANG Project; **Cosmic Microwave Background radiation.** DMR, COBE, NASA, Four-Year Sky Map

knowledge about astronomy for a whole generation. He accomplished this by communicating complex ideas in simple ways, yet without oversimplifying them. He *could* do this because he convincingly, deeply understood what he was talking about — an unusual characteristic for the host of a television show.

But times have changed since 1980, along with our understanding of the universe. Sagan's performance, material, and his influence on the world were stellar, and it was a shame that he had to put up with peevish colleagues who felt that popularizing science amounted to selling out. But consider how fundamentally different the landscape of astronomy and cosmology now looks relative to 22 years ago. In 1980, Alan Guth's concept of inflation was brand new, not yet refined or taken seriously. A clear understanding of superclustering of galaxies, the "great attractor," and modern cosmic microwave background studies were all yet to come. No one knew anything about gamma-ray bursts or extrasolar planets or dark energy. The distance scale of the universe was only crudely defined, as the Hubble Space Telescope's measurements of variable stars in distant galaxies were then only a pipe dream.

The solar system has also changed. We knew nothing of what would come from Halley's Comet or from the collision of Comet Shoemaker-Levy 9 into Jupiter. Voyager 2 was still heading towards Saturn. The Kuiper Belt and the hoards of trans-Neptunian objects were all mere speculation, while numerous moons and other solar system residents we now have safely catalogued away were undreamed of. In short, it was a very different universe back then. Looking at the big discoveries and advances in understanding over the past two decades gives us insight into how fast our knowledge of astronomy is zooming ahead — and hints at answers to some of astronomy's big questions that might lie just around the corner.

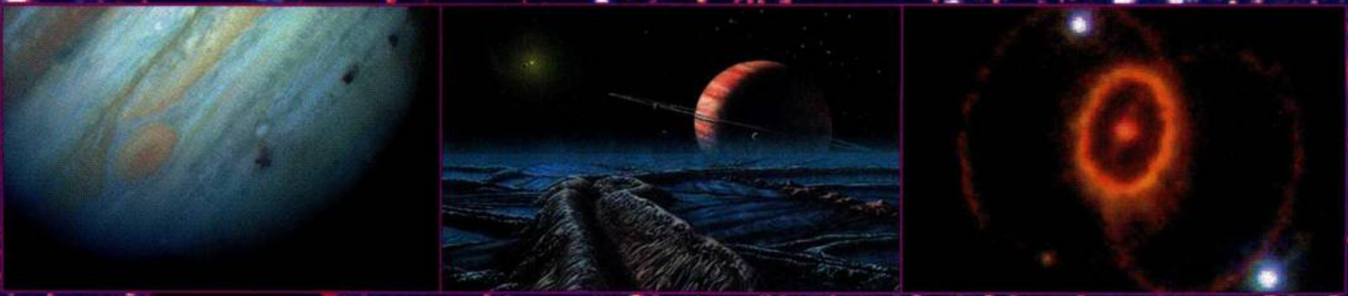
An Evolving Universe

As Sagan worked on the production of *Cosmos*, the Big Bang theory of the origin of the universe was pretty well accepted by nearly all cosmologists, with a few notable, vocal exceptions. It seemed to explain so much of what was visible in the universe today. Yet wrinkles in what was observed could only be resolved by a slight modification. In 1979 this led a young professor, Alan Guth, now at MIT, to formulate the concept of inflation — an immense burst of expansion that followed the Big Bang, very early on, and increased the size of the universe by a factor of 10^{50} in a very brief time. Many modifications of the idea have evolved over the past 23 years, by Guth himself, Stanford physicist Andrei Linde, and others, and the case seems as strong as ever that inflation did occur. This means the universe may be in fact much larger than the one we have thus far observed. It raises the intriguing (though unknowable) possibility that our universe could be one of many, like bubbles encased in an infinity of "big bangs."

As many astrophysicists carried the theoretical possibilities far beyond the visions of *Cosmos*, astronomers were busy observing the distribution of galaxies. In 1982 John Huchra of the Harvard-Smithsonian Center for Astrophysics studied the motions of galaxies in the Local Group and the Virgo Cluster and found they were being pulled toward Virgo. The resulting discovery of a "great attractor," a proposed massive supercluster beyond the Hydra-Centaurus Supercluster, was amazing. In 1986 Huchra and colleague Margaret Geller commenced a massive survey of galaxies to magnitude 15.5 in a wedge of sky 6° wide and 120° long, recording objects out to 300 million light-years' distance. Their subsequent discovery of great voids and superclusters of galaxies was stunning, revealing the lack of a uniform distribution of galaxy groups. The largest structure observed, dubbed the "great wall," appeared to be a thin sheet of galaxies stretching 500 million light-years without an edge.

When production on *Cosmos* got underway, funding was approved by NASA and other agencies for a long-envisioned space telescope. By 1990, what came to be called the Hubble Space Telescope, a 90-inch instrument that would capture starlight above the distorting effects of Earth's atmosphere, was launched via the space shuttle. Two months after launch, the shock came. A simple error in figuring Hubble's mirror had left it with a bad case of spherical aberration. In 1993 a shuttle servicing mission retrofit the scope with corrective optics and it began a career as the most revolutionary instrument turned skyward since Galileo's telescope in 1610. Among Hubble's most significant achievements were the 1994 discovery of the existence of a black hole in the center of active galaxy M87 in Virgo, and the incredibly precise collection of distance scale data made by the members of the Hubble Key Project. Led by Caltech astronomer Wendy Freedman, the Key Project started in the early 1990s with the goal of measuring Cepheid variable stars in galaxies with HST in order to fix the Hubble Constant, and therefore the distance scale of the universe, to an accuracy of ±10 percent. Some 28 astronomers are now working on the project.

Such projects have led to vigorous debate between disparate camps of astronomers. In April 1920 Harlow Shapley and Heber D. Curtis held the first such grand debate, in Washington, D.C. In 1996 a second great debate on the scale of the universe



Advances in astronomy, like many made in the last 22 years, will continue in the coming decades. From left to right: Jupiter and Comet Shoemaker-Levy 9. SEDS; **An artist's conception of extrasolar planets.** Lynette Cook; **Supernova 1987A.** Hubble Space Telescope

took place between Sidney van den Bergh and Gustav Tammann, in the same auditorium used 76 years earlier. Van den Bergh offered evidence supporting a high value of the Hubble Constant (about 80 km/sec/Mpc), suggesting a young age and relatively small size of the universe, while Tammann argued for a low value of the constant (about 55 km/sec/Mpc), which would result in an older, larger universe. More recent research carried on the vigorous cleft between these two camps, which were essentially led by Freedman (the younger, smaller universe) and Allan Sandage of the Carnegie Institution of Washington, the intellectual successor to Hubble (older, larger universe). The most recent series of measurements from HST, from the late 1990s on through today, seem to continue to strengthen the case for the Freedman group.

Meanwhile, although when *Cosmos* first aired most people believed in the Big Bang firmly, the curious hypothesis seemed to collect a microcosm of disbelievers that slowly, quietly grew through the 1980s and 1990s. But during the past couple of decades the Big Bang received ironclad supporting evidence from several different sources. In 1992 George Smoot of Lawrence Berkeley Laboratories, John Mather of NASA's Goddard Space Flight Center, and colleagues published data from the Cosmic Microwave Background Explorer Satellite, showing fluctuations in the cosmic microwave background radiation, as predicted by Big Bang theory, and which also supported inflation. Further significant evidence came in 2001 from balloon-borne instruments employed by the BOOMERANG and MAXIMA teams measuring the microwave background radiation and from direct measurements of temperatures in the early universe (age = 2.5 billion years) with the Very Large Telescope in Chile, in late 2000. Earlier evidence came of course from the tracing of galaxies' velocities backwards and from cosmic nucleosynthesis.

Back in that same old room in Washington, another landmark debate took place in 1998 — this time on the nature of the universe. The debaters were now Jim Peebles of Princeton University and Michael Turner of the University of Chicago. The question to be debated was, "Is cosmology solved?" Turner boldly contended that cosmologists had by then put together a

Is *Cosmos* Worth Watching Today?

Last year, after not seeing any of the *Cosmos* footage for some years, I popped one of the tapes into the VCR and watched Episode 1, "The Shores of the Cosmic Ocean," with my family. A flood of memories came back, as did the information, the history, and the professor with the hair, the sweaters, the jackets with the elbow patches, and the alleged — if not actual — zeal for the word billions. I found the content still gripping, the production techniques still alluring. Remember the "spaceship of the imagination?" The message and pacing of the show created a big success with our then-eight-year-old son. The sharp, piercing tones of the theme music and the special effects such as the Alexandrian Library in miniature held up pretty well. Yet the whole thing, aside from the advances in scientific knowledge that have occurred over the past generation, felt a little dated, like we were gazing into a 1970s time capsule.

All this raises the question, "Is *Cosmos* worth watching now?" It's a valid question; in 2000 Cosmos Studios, the company operated by Ann Druyan, Sagan's wife and coauthor of the series, issued an enhanced version of the product on DVD and VHS. It's available at the studio's website, www.carlsagan.com. The improved version contains some updates by Sagan and Druyan, as well as new astronomical images and bulletins. The seven-tape VHS set goes for $133.95; the DVD boxed set is $169.95; and an audio 2-CD set featuring music retails for $25. An abridgment of the series, *The Best of Cosmos*, aired on PBS in late 2000.

NASA

Cosmos's validity in 2002 is still solid; it has aged well. Much of the material Sagan guides viewers through consists of background stuff, establishing a baseline understanding of the history of science and astronomy. As for the conclusions about the status of astronomy in 1980, it's pretty interesting to see where things stood more than 20 years ago, provided that you know where they've gone since. And something that can't be easily measured comes out of re-watching the series — learning how to appreciate science from one of the recent masters, who sadly now is gone. — *D. J. E.*

mosaic of data into a coherent picture that describes the origin, evolution, and current state of everything. Peebles advised caution, believing that many wrinkles in what we now think will still pop up. It's a fortunate thing that he did. That same year, Saul Perlmutter at Lawrence Berkeley Labs and his collaborators in the Supernova Cosmology Project — along with Mount Stromlo and Siding Spring Observatory astronomer Brian Schmidt's High-z Supernova Search Team — found evidence to suggest that not only is the universe expanding, as Hubble found, but that the rate of expansion is speeding up; the universe is accelerating. The result came from observations of extremely distant supernovae. That stunning discovery seemed to reawaken the cosmological constant, the "fudge-factor" that Einstein had termed his "biggest blunder," back into validity. The universe was not slowing down as everyone had thought. It also suggests strongly, along with other bits of evidence, that the universe will go on expanding forever.

Searching for Answers

Three years later more stunning news rolled in on the accelerating universe front. By looking at other distant supernovae with the Hubble Space Telescope, Adam Riess of the Space Telescope Science Institute found that a mysterious form of "dark energy" must be pushing the galaxies apart. A supernova of record-breaking distance used as a probe some 10 billion light-years away not only suggested that the old concept of dark energy — first proposed by Einstein — was a reality, but that the acceleration of the universe must have begun relatively recently in its history. Bright matter and even dark matter — the still unknown form of stuff that surrounds galaxies in great quantities — must together account for a total of only about 35 percent of the universe's energy density. The other 65 percent lies in dark energy.

The search for dark matter answers labors on. The suspects include huge numbers of normal neutrinos, MACHOs (massive, compact halo objects) such as brown dwarfs, white dwarfs, neutron stars, or black holes; WIMPs (weakly interacting massive particles) such as exotic particles, axions, massive neutrinos, or photinos; and intergalactic hydrogen gas. Another peculiarly unresolved topic in astrophysics is the identity of gamma-ray bursts, ultrahigh energy flashes of gamma rays observed by satellites that last from a fraction of a second to several minutes, and which have been seen since the 1960s. The debate that has raged over these objects has centered on whether they are relatively near, relatively lower energy events or extremely distant, unbelievably energetic events. As with all great astronomical controversies, a great debate occurred on this topic, too, in 1995. The evidence now seems to be leaning toward the latter, and it may be that some or all of these events represent colliding black holes or neutron stars or exotic supernovae.

I think of all the vast changes in astronomy over the past two decades, Carl Sagan would probably have been the most excited over the progress in detecting extrasolar planets. After all, by mid-2002, more than 100 had been found, such that we have found ten times as many planets outside the solar system as in it. And the question of extraterrestrial life certainly gnaws at each of us. It's not good enough to know the numbers game — that 200 billion stars in a galaxy times 125 billion galaxies give us one heck of a lot of potential planetary systems for possible life. Nor is it satisfying to sit back and rest on the goofy notions of Hollywood toward alien creatures, all based on earthlike life structures and in two simple-minded varieties — either squishy and lovable or hostile and razor-toothed. We'd like to know how many earthlike planets are really out there; those we can detect now are huge, Jupiter-like worlds. But space telescopes will be coming that should be capable of detecting earthlike planets, and in 2002 David Charbonneau of Caltech made an amazing leap forward by using Hubble to detect the first atmosphere around an extrasolar planet orbiting HD 209458, a yellow, sunlike star.

How many big changes on the home front, in our cosmic backyard, have occurred since *Cosmos*? Lots. We witnessed the beauty of Halley's Comet, Comet Hyakutake, and Comet Hale-Bopp. In 1994 the world collectively gasped as we watched Comet Shoemaker-Levy 9 pull apart and slam into Jupiter's cloud tops. Caught off guard by a brilliant supernova in the Large Magellanic Cloud in 1987, we followed the huge stockpile of scientific results that came from such a nearby stellar show. We saw Voyager 2, which had explored Jupiter in time for *Cosmos*, go on to explore Saturn in August 1981, and the gas giants Uranus and Neptune in 1986 and 1989. Many new solar system moons have been found along the way, as has the existence of the Kuiper Belt and many more near-Earth asteroids. We also experienced the lowest point of the space program's history when Challenger exploded in 1986.

It was a great tragedy for astronomy when Sagan died in 1996 at age 62, unable to see the answers to some of the questions he desperately wanted people to consider. We can only hope that the astronomy world will again find a popularizer with the understanding and grace of Sagan. ■

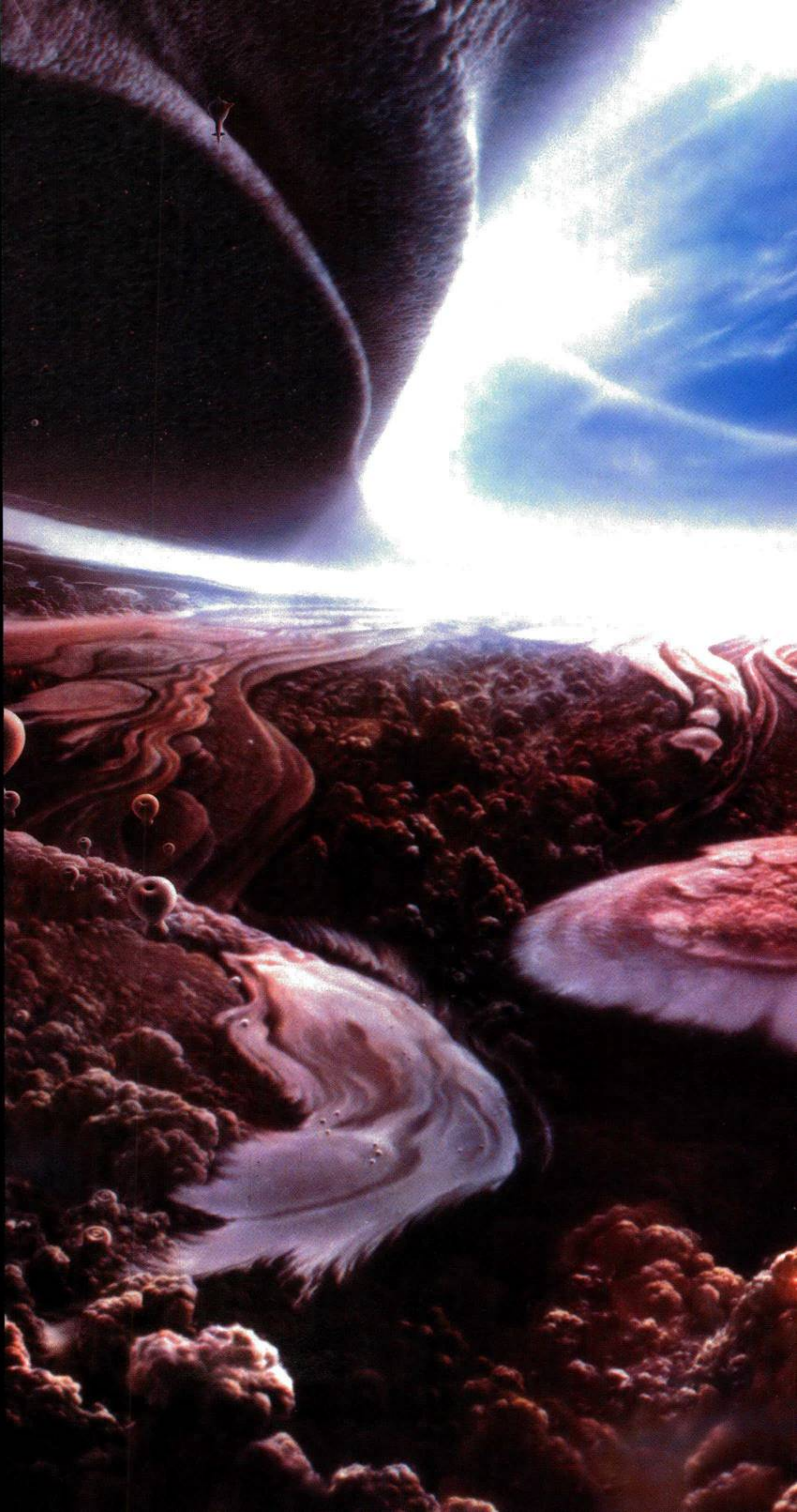
David J. Eicher is managing editor of Astronomy. *In 1977 he founded and began publishing* Deep Sky Monthly *based in part on Carl Sagan's advice.*

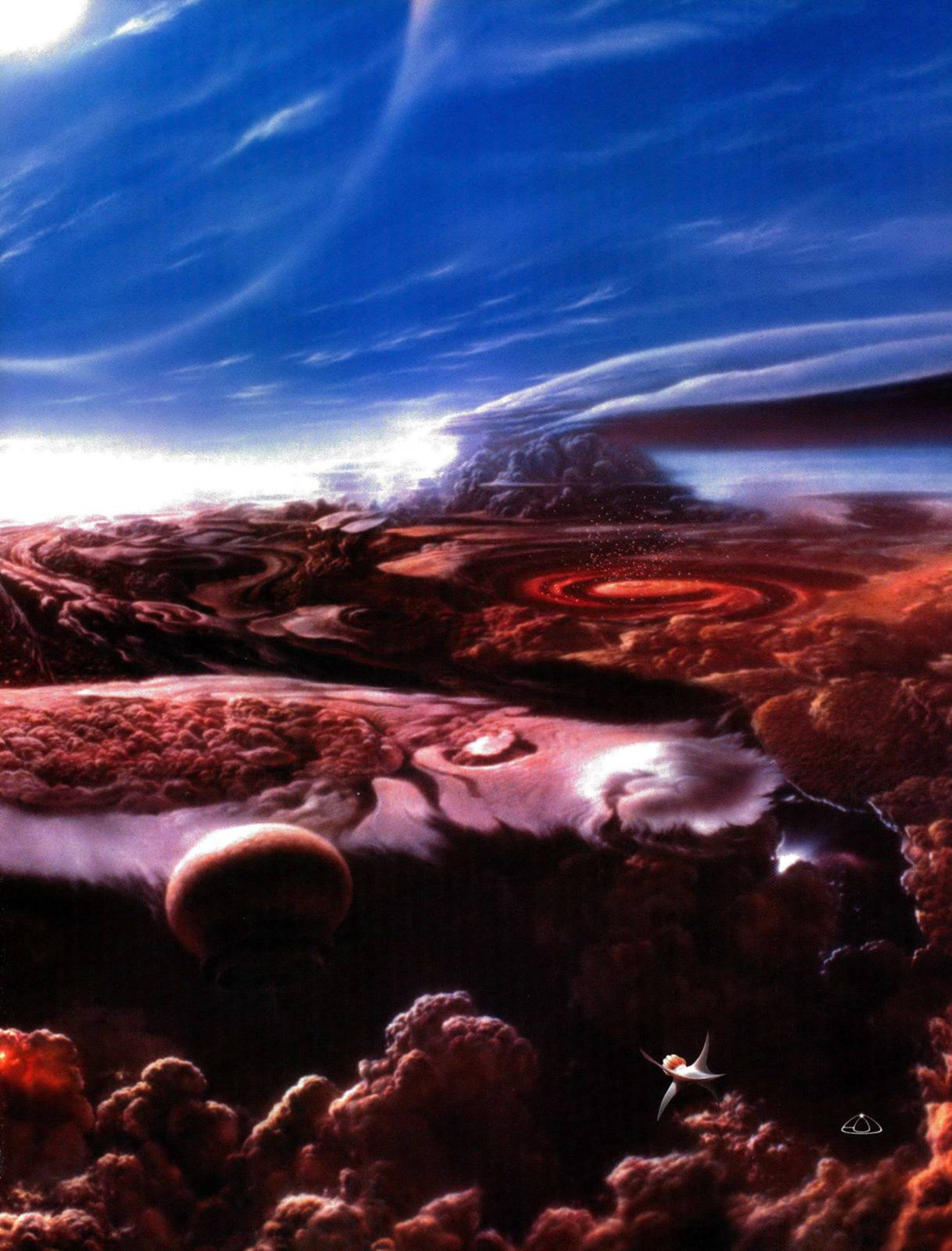
The spiral galaxy NGC 2613 in Pyxis holds several hundred billion stars. Are life forms staring back at us from its reaches? ESO

The Artists Behind the Wonder

Creative visual effects influenced the enormous impact of Carl Sagan's landmark series.

by Richard J. Bartlett
with Adolf Schaller





Previous pages: Space artist Adolf Schaller set out to paint the "hypothetical jovian-type gas giant world" that Sagan wanted for *Cosmos*. He incorporated every conceivable life form consistent with cloud images taken as Voyager flew by Jupiter.

"The cosmos is all that is or ever was or ever will be," proclaimed Carl Sagan in 1980 in the first episode of his 13-part series, *Cosmos*. It was the beginning of a personal voyage that Sagan shared with an estimated half a billion others in more than 60 countries. This public television program, written by Sagan, Steven Soter, and Sagan's future wife, Ann Druyan, was originally entitled *Man and The Cosmos*. But Druyan convinced Sagan that the title was sexist. And so, *Cosmos* was born.

Cosmos marked many firsts, one of which was the use of groundbreaking astronomical art to reveal worlds previously unseen by astronomy enthusiasts.

"For the rest of our happy lives together, Carl remembered my stand on this issue, always with a sigh of relief, followed by a gallant gesture of gratitude," says Druyan.

The series marked many firsts, one of which was the use of groundbreaking astronomical art to reveal worlds previously unseen by astronomy enthusiasts. This is the behind-the-scenes tale of how the artists worked on the series, what their roles were, and how they contributed to the end result. Sagan assigned illustrator Jon Lomberg the role of chief astronomical artist for the series. Lomberg then became responsible for assembling the team that would produce the art and special effects for *Cosmos*. In September 1978 he contacted another astronomical artist, Adolf Schaller.

Born in Chicago, Illinois, in 1956, Schaller became interested in astronomy after witnessing a summer fireball during a Wisconsin fishing trip. No older than seven at the time, he experienced a spark of interest that grew until he entered high school, when he began to dabble in astronomical art.

In the ensuing years, Schaller's art appeared in numerous publications, including *National Geographic* and the *Encyclopedia Britannica*. He'd already met Sagan briefly, so when the call from Lomberg came, he jumped at the chance to work on the series.

Schaller joined fellow artists John Allison, Caroline Brown, Don Davis, Anne and Ernie Norcia, and Rick Sternbach. Collectively, they became known as the *Cosmos* artists. Additionally, Pat Cole and Jim Blinn of the Jet Propulsion Laboratory created the computer animations used in the series.

By the end of 1978 each of the artists was working on his or her own contributions. One of the first sequences conceived was the opening title shot, known as the "Cosmic Zoom." Lomberg and Sternbach started the production sketches and storyboard paintings for the sequence, while Schaller worked with Lomberg's guidance. "I prepared a sequence of four paintings illustrating the gradual growth of the sun at the end of its life," recalls Schaller. He finished the first panel, titled "The Last Good Day," in December 1978. Sagan loved it, approved it, and subsequently renamed it "The Last Perfect Day." He shipped it to KCET, the public television station in Hollywood, California, and headquarters for *Cosmos*, for production.

Lomberg also requested that Schaller conceptualize Sagan's ideas involving hypothetical aerial life forms (referred to as "hunters, floaters, and sinkers, or HFS") that could inhabit the atmosphere of a gas giant planet such as Jupiter. In February 1979, Schaller arrived in Los Angeles with about 150 pencil sketches and immediately began work on the production. By the end of his first day, he had completed three "planes" of a 3-D depiction of the Milky Way.

"In the weeks following my arrival, I also had a number of other projects to keep me busy, including the completion of the 'Last Perfect Day' sequence, a Jupiter model, and the HFS painting," says Schaller. Meanwhile, as Don Davis was busy creating a Titan landscape, Voyager 1 was nearing Jupiter. The artists worked from the latest images received by the Jet Propulsion Laboratory (JPL) in Pasadena.

Schaller soon realized he wouldn't be able to paint the atmospheric features of Jupiter at the correct scale in the required detail, so he worked out a compromise. "The best way was to enlarge the scale of the Great Red Spot region by two hundred percent," he says. When Sagan saw the Jupiter globe, he admired its authentic look, then asked, "Isn't the Red Spot a little too big?" In response, Schaller says he aimed a spotlight at the Jupiter model to present a crescent phase. He instructed Sagan to walk toward the model as if he were the camera and try to mimic the trajectory of the first Voyager flyby. Delighted at the exercise, Sagan laughed, saying he had always wanted to personally fly by Jupiter. In the series, viewers approach Jupiter from an angle and the Great Red Spot isn't visible at first. As the perspective appears to draw closer and move around the planet, more and more surface features — including the Red Spot — become visible. The extra dimensions Schaller imparted to his Red Spot added a special drama to the scene.

Next came Sagan's inspection of the HFS painting. When Sagan saw Schaller's HFS painting, he couldn't keep his eyes off it. He stared at it less than a foot away with a great grin on his face. He exclaimed, in that distinctive Sagan way, "This is *marvelous work! It's fan-*

tastic!" When Schaller expressed his reservations about finishing all nine panels in the short time frame, Sagan replied, "But wouldn't it be great to see it whole?"

"At that point I just fell silent," says Schaller. "I worried that I wouldn't have enough time to do everything." Schaller then showed Sagan the other two panels he'd been working on. Sagan gasped, "It looks as though we're actually there, floating among the clouds."

And that's pretty much how Schaller felt on March 5, 1979 as he sat watching images from Voyager 1 in the JPL lobby. Hypnotized, he saw the craft make its closest approach to Jupiter at a distance of 168,000 miles (280,000 km) from the gas giant. It inspired him to complete the Jupiter globe within days of the flyby. After that, he concentrated on finishing his HFS paintings.

Technicians built a special camera for shooting the multi-plane artwork and models while the artists scrambled to complete their work. Early footage proved unusable, and a backlog piled up. What began as a months-long shooting schedule was condensed into about two weeks. Everyone worked around the clock. "I spent the first day readying the panels and work area, then settled in for a grueling 20-hour-day schedule," Schaller recalls. Some days he didn't sleep at all, instead working on the HFS in the sunny solitude of the loft above the apartment he now shared with John Allison. He placed all nine panels — a total area of 75 square feet on the living room floor and viewed them from above. "I would select one or two panels to work on at a time," says Schaller. "Progress on it went smoothly and steadily."

Technicians built a special camera for shooting the multi-plane artwork and models while the artists scrambled to complete their work.

To save time, Schaller concentrated on the inner regions of each panel, but with shooting just a few days away, he was forced to move the panels to KCET. They were mounted onto a 7½' by 10' framework; work began on the seams between each panel. But Schaller had been up for more than 48 hours by then and had difficulty keeping his eyes open.

"Declaring it finished, I watched as they suspended the frame from ceiling cables on the soundstage," he says. Too tired and bleary-eyed to stay awake for the rest of the shoot, he left. The next day series director Adrian Malone told Schaller that, "Everything went splendidly. Your masterpiece helps the show a lot."

In the United States, *Cosmos* premiered on PBS on Sunday, September 28, 1980. Each of the *Cosmos* artists won an Emmy, and the companion book became the best-selling science book ever published in the English language. It included artwork featured in the series as well as contributions from other established artists. One of those whose work was featured in the book is space illustrator David A. Hardy. "I remember watching *Cosmos* and being highly impressed," says Hardy, from Birmingham, England. "The special effects were state-of-the-art at the time, and I particularly liked that 'thistle-down' spaceship of the imagination."

Cosmos and its special effects profoundly influenced Daniel D. Durda, a senior research scientist at the Department of Space Studies in Boulder, Colorado. "Carl led by example and showed that not only is it okay to popularize science, it's also an important part of what we do — to communicate the excitement and wonder of the cosmos around us to others," he says. Durda spent a great deal of time during his undergraduate years reading everything he could find on extrasolar planets. "Now, of course, new [planetary] systems are being discovered all the time," says Durda.

Astronomer Geoff Marcy also believes that *Cosmos* affected him on a personal as well as professional level. With the discovery of more than 45 extrasolar planets, Marcy and his team at the University of California at Berkeley and San Francisco State University are at the forefront of such work. "Carl Sagan in *Cosmos* articulated the intimate connection between our galactic neighborhood and our precious planet Earth," says Marcy. "Our bodies and all the life on Earth are composed of ingredients that came from the stars."

In the final episode of the series, Sagan asked, "Who speaks for Earth?" It's a question that many still ask today. Some might nominate Sagan himself and yet words alone cannot do justice to the universe in which we live. Sagan knew he needed the help of artists to bring his dreams and ideals to life. In the men and women who worked on *Cosmos*, he not only found the people who could realize his vision but also those who shared his wonder and his passion for the cosmos.

If we could ask Sagan that same question today, no doubt his answer would be the same as it was 20 years ago: "We speak for Earth. Our obligation to survive is owed not just to ourselves but also to that cosmos, ancient and vast, from which we spring."

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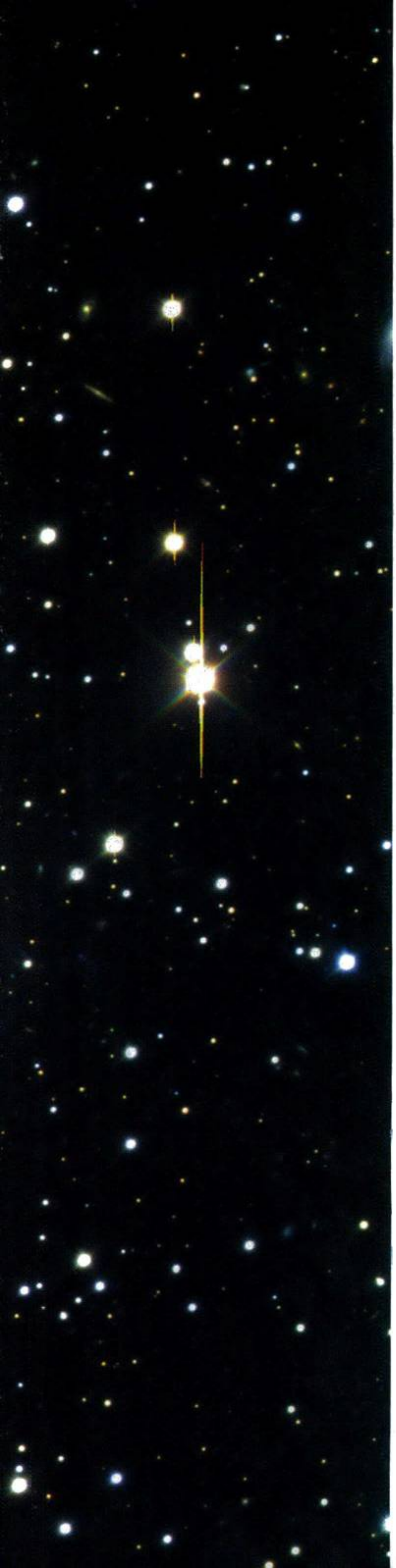


ESO

Using Lasers to Detect E.T.

Seeking intelligent life in the universe, SETI begins a new optical search.

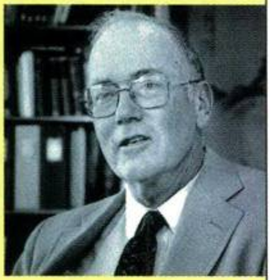
by Steve Nadis

The search for intelligent extraterrestrial life took a turn in 1997 when SETI channeled some of its resources toward optical search strategies. After all, an alien civilization might be beaming us with lasers rather than sending radio waves — SETI's exclusive target for many years. With lasers doubling in power every year for the past 40 years, it's now possible to create a brief pulse that's 5,000 times brighter than the sun. More advanced civilizations might be able to outshine their parent star a million-fold. Whereas radio waves can better penetrate an atmosphere, lasers carry information more efficiently and are not dispersed by the interstellar medium to the same extent.

Charles Townes: Optical SETI's First Champion

Some 40 years ago, Charles Townes had an idea that was decades ahead of its time. This, of course, was nothing new for the University of California, Berkeley, physicist, who won the 1964 Nobel Prize in Physics for his role in inventing masers and lasers. Upon reading a 1959 paper suggesting that radio waves would provide the best means of extraterrestrial communications, Townes thought, "Wait a minute. Lasers could do it too." Since then, he has steadfastly argued against a fixation on radio, imploring his colleagues to consider light waves as well as other types of waves.

His case for interstellar and interplanetary communications with lasers was first presented in a 1961 *Nature* paper he wrote with Robert Schwartz. Townes was research director for the Institute for Defense Analysis, where Schwartz served as staff scientist. Townes believes this was Schwartz's one and only foray into optical SETI, whereas Townes has been a relentless advocate for four decades. "However, it took more than 30 years for the SETI community to catch on," he says.



For example, SETI pioneer Barney Oliver dismissed the idea of optical searches in his influential "Cyclops" report that NASA published in 1971. Oliver's skepticism was shared by many peers. "Radio was a habit of mind that people were stuck in," Townes says, while conceding that early lasers were feeble. But the technology has advanced so that for extremely brief intervals in specific wavelengths, man-made devices can outshine the sun.

Although radio technology matured earlier than laser technology, it could easily have been the other way around, Townes maintains. "The basic ideas for lasers were known as early as 1920 by a variety of people. My contribution was putting it together — a combination of engineering and physics." He's convinced that any civilization advanced enough to achieve sophisticated radio know-how should be able to produce lasers as well. "And we don't have to go far beyond present capabilities to shine a beam to a planet that could be seen with human eyes," he adds. "It would take another order of magnitude boost to do that. But the effect would be so striking that any intelligent creature would think: What does that mean?"

Interference — a growing headache for radio astronomers — is not a problem in optical wavelengths. Searchers could look for bright flashes in any part of the optical spectrum, without having to make guesses in advance about "magic frequencies."

Dan Werthimer, recruited to head up a working group on optical SETI (OSETI), hadn't given it much consideration. He had been preoccupied with SERENDIP, a powerful radio search he ran using the Arecibo telescope in Puerto Rico. But he'd heard a lot about OSETI over the years, having worked since 1982 at the University of California, Berkeley, alongside Charles Townes, who invented the laser and pushed its use in the E.T. search. Scattered optical searches occurred over the years, including work by amateur Stuart Kingsley. OSETI began in earnest in the late 1990s, 35 years after Townes suggested it.

Townes periodically promoted his idea, and in 1997, Werthimer finally listened: He fashioned an instrument capable of detecting billionth-of-a-second (nanosecond) laser pulses, which would appear as repeated bursts of photons arriving at the same time, rather than the one-photon-at-a-time pattern characteristic of ordinary light. He tested the device at Leuschner Observatory before the working group convened later that year. "I built it as a demonstration to stimulate discussion. I wasn't planning to start an observing program."

Harvard physicist Paul Horowitz improved on Werthimer's instrument, and initiated a pulsed laser search in 1998. Werthimer began regular observations at Leuschner in 1999, the same year Berkeley planet hunter Geoff Marcy decided to comb through his Keck data for hints of laser signals. Another pulse search started later at Lick Observatory using technology Werthimer and his Berkeley colleague, Richard Treffers, designed. A Princeton telescope entered the arena in late 2001, and a new Harvard telescope is due to come online in 2002.

Still there are some drawbacks: Laser beams are so directed that optical searchers cannot pick up accidental "leakage," such as broadcasts of *I Love Lucy* that have already gone past 10,000 stars; we can only see something if aliens are intentionally targeting our planetary system. Attenuated by galactic dust, laser intensity drops off with distance, limiting the range for OSETI to about 1,000 light-years. But roughly one million stars lie within that radius.

At this stage, the Harvard program — which began in October 1998 and has since made about 22,000 observations of 7,000 sunlike stars — is farthest along. Horowitz's laser detector is hooked up to a 61-inch telescope at the Oak Ridge Observatory, which is used primarily for extrasolar planet searches; about one-third of the telescope's light is diverted to the OSETI team without penalty to the planet seekers. Some 15,000 stars will be looked at in all. "We're getting an incredible free ride on the biggest optical telescope in the East," Horowitz says.

The effort has been plagued by false alarms, about one a night, but that will soon be a problem of the past. Encouraged by Freeman Dyson, Princeton astronomer David Wilkinson asked Horowitz whether there might be any use for a 36-inch telescope that had been idle for 30 years. The two quickly realized the potential benefits of having a pair of synchronized telescopes, 300 miles apart, looking at the same star at the same time. The Princeton telescope was turned on for this purpose late in 2001. "This will provide an instantaneous check on the validity of a signal, giving us much more confidence in a single detection," Wilkinson says. "If we see anything interesting, we'll want to follow that star closely for months." The astronomers would look for a repeating signal that appears to be artificial in origin, ideally with a discernible pattern.

The Drake Equation

Aside from Earth, does intelligent life exist in the universe? In 1961 Frank Drake of Cornell University devised a formula to estimate the number of communicative civilizations in the Milky Way, which came to be called the Drake Equation. It consists of seven input variables. If we can accurately estimate the values of these variables, such as, "The number of earthlike worlds per planetary system," we should have a fair idea of how many civilizations exist in the galaxy. Astronomers have a good idea of what a couple of the values are; some require an educated guess because astronomers, as yet, have only one civilization to work with — our own. To estimate how many civilizations might inhabit the Milky Way, follow these eight steps. Don't care for algebra? Go to Astronomy.com and we'll do the math.

— Tom Ford

$$R^{*} \times fp \times ne \times fl \times fi \times fc \times L = N$$

1] The variable "R*" represents the formation rate of suitable, or sunlike, stars per year. As few as five or as many as 1,000 are created each year in the Milky Way, 5% of which are sunlike.

Anywhere between 1 and 50 is a good guess.

2] The variable "fp" is the percentage of these sunlike stars that have planets. We've detected dozens of Jupiter-like planets orbiting stars, so we can assume planet formation is fairly common.

Try something between 0.5 and 1.

3] The variable "ne" represents the number of habitable planets per system. We still lack the technology to detect them. Our system has one — Earth — and the jury's still out on whether Mars was once habitable.

Use 1 for now.

4] Here's where it starts getting tricky: The variable 'fl' is the percentage of habitable planets where life develops. It's possible — we're *living* proof. If life was found to exist on Mars we might even think it was probable.

Try a number between 0.5 and 1.

5] More speculation: "fi" represents the percentage of living worlds where intelligence develops. Since we're pondering the question we know it's happened once.

Again, try something between 0.5 and 1.

6] The variable "fc" represents the percentage of aforementioned planets that have the technology to communicate. We've been sending radio waves for over a half a century so far. Some may have the means but choose to be quiet.

Let's use a number between 0.9 and 1.

7] One more to go: "L" is the duration a communicating civilization lasts in years. Earth could turn from a radio-wave producing planet into a weak gamma-ray source in less than fifty years.

Be optimistic and enter in a number substantially greater than your lifespan.

8] Almost done! Multiply all seven variables to calculate your answer "N". You've estimated the number of other communicative civilizations residing in the Milky Way! 10^{13}. Fortunately our certainty of these variables becomes greater every day.

Led by Horowitz and graduate student Andrew Howard, the Harvard team is also gearing up for OSETI's first all-sky survey, which should begin this year. The finishing touches are now being put on a new observatory housing a 72-inch telescope, which will be the biggest optical telescope in the East, and the first large telescope built specifically for OSETI purposes. "The targeted search looks at just one-one millionth of the sky, but that's a pretty interesting one millionth," Horowitz notes. "The new search will look at the entire sky, but we only have about a minute for each patch, which makes it pretty tough for the aliens. That's why we'd like to do the survey several times."

Meanwhile, projects on the West Coast are proceeding apace. Werthimer and his colleagues have used an automated 30-inch telescope at Leuschner to look at about 2,500 stars since 1999, with another 7,500 still on their target list. A 40-inch telescope at Lick Observatory was turned on in December 2000 to look at 5,000 stars within 200 light-years of Earth. Both telescopes use three detectors in order to hold false alarms to only about one a year. "Getting a false alarm is inconvenient because you can spend a long time following up on a star," explains Lick astronomer Remington Stone. On the other hand, if a pulsed signal seems "real," rather than an equipment artifact, they'll look for a repeat. "If we confirm that, we'll ask Leuschner to look at it," he adds.

Geoff Marcy and his graduate student Amy Reines are trying an entirely different tactic, sifting through high-resolution spectral data of 600 nearby stars for a narrow emission line that might represent an artificial light source operating either in a pulsed or continuous mode. "The idea is to compare observations of the same star over time; if something looks really different, it might be due to a laser," Reines explains. "Anyone who has a lot of high-quality stellar spectra can use this technique if they have multiple observations of one star."

If the history of science is any guide, says Horowitz, "The data mining approach employed by Marcy might be the way we find a signal like this. More things are found when you're not looking for them." Werthimer agrees with that assessment, but says that doesn't mean OSETI is futile.

"Even though there's a 50–50 chance the person who discovers the signal won't be doing SETI, it's still worth doing this stuff — if only to help non-SETI people stay on the lookout." There's always the concern with SETI that since they are relatively new to the game, they might not be going about it the right way. "Maybe they're sending zeta waves we haven't discovered yet," Horowitz muses.

Even back in 1961, Townes asked, "What other methods are we overlooking that might appear natural to some other civilization?" Townes speculates that aliens might be sending particles of some form or x-ray lasers that we're not presently equipped to search for. But we are capable of both sending and detecting infrared lasers, which might be a reasonable way to communicate. Infrared lasers can penetrate dust clouds better than optical lasers and would be easier to distinguish from starlight. An infrared detector would have to be cooled to about 7 Kelvins, which is expensive though perfectly feasible. Both Horowitz and Werthimer see this approach as SETI'S next frontier and hope to get in on the act. Of course, for infrared SETI to really take hold, it will need an acronym — ISETI being the obvious choice. In fact, the term could serve as a convenient form of shorthand in the event of contact with an intelligent civilization. If brevity is a priority, our response to the first alien signal might be: "ISETI. Who you?"

Paul Horowitz:
Applying Technical Wizardry to the Search

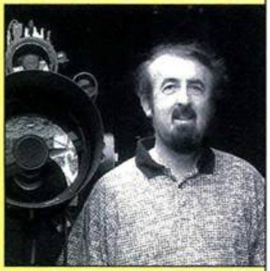
Paul Horowitz is a marvelous anomaly in the Harvard physics department. While his colleagues are making Bose-Einstein condensates, slowing light to a standstill, or concocting the latest in superstring theory, he has devoted himself for the past 20-odd years to bringing technical virtuosity — on both radio and optical fronts — to what he considers the greatest search on Earth. If anyone looks askance at his extraterrestrial proclivities, Horowitz couldn't care less. "We're the first generation capable of doing this search, and it's so much fun to try," he says. "How can you put your head in the sand and say we shouldn't be interested in intelligent life in the universe?"

Horowitz has not always been SETI's most enthusiastic supporter; his work was more mainstream before he entered the E.T. business. In 1980, for example, he wrote *The Art of Electronics*, which became the classic text in a traditionally down-to-earth field. But his desire to reach out manifested itself early. At age seven, he was reportedly the world's youngest amateur radio operator, delighting to the sound of communications from afar. Fifty-two years later, he's still at it, but casting his net into the Milky Way.

During a sabbatical from Harvard in 1977 to 1978, Horowitz spent time at Arecibo conducting what still stands as one of the most sensitive SETI searches ever done. Since 1983, he has led a series of increasingly sophisticated radio surveys at a telescope 40 miles west of Boston, culminating in BETA — a 250-million channel search that began in 1995.

Three years later, he began a targeted optical search of 15,000 stars at a nearby telescope. His interest in optical SETI was sparked by a 1995 talk on the subject by Charles Townes. "I was blown away," notes Horowitz. His next step was to persuade a team of Princeton astronomers to join in the targeted search in late 2001. Another milestone will be achieved in 2002, when he and his colleagues launch OSETI's first major all-sky survey. Although Horowitz thrives on the challenges of designing evermore advanced techniques for detecting signals, he believes SETI will eventually shift to discovery. "We won't be searching forever," he says. "At some point, we'd like to start following up on a finding." That's when the fun will really begin. —S.N.

Stuart Kingsley: A Man on a Mission



In 1990, when his electrical engineering career was in the doldrums, Stuart Kingsley had a lot of time on his hands and he decided to investigate optical SETI. At the time, he'd been interested in SETI for about 20 years, but the articles he read were always about radio SETI, never optical, and he wanted to know why. Some might have read Schwartz and Townes's landmark 1961 paper and left it at that, but the idea pulled Kingsley in "like a black hole." After convincing himself that lasers were far superior to radio for intragalactic communications, he's been promoting OSETI by writing on the subject, organizing three international conferences and building a prototype observatory in his backyard in suburban Columbus, Ohio.

Kingsley's efforts have been praised by Paul Horowitz, Charles Townes, and Dan Werthimer, among others. "He understood that OSETI was a good thing before Dan and I did," says Horowitz. "He's played an important role by then pushing this idea forward."

Kingsley completed his modest observatory — with a 10-inch telescope and 10-foot dome — in 1994, though the facility is currently closed for renovations. Before it reopens, he'll have to arrange to have his neighbors' trees trimmed — one of the special challenges of a backyard operation. "I've paid for all of this myself, so I can't expect to compete with full-time astronomers at Harvard and Berkeley," he says. "But I never wanted to compete with them. I just wanted to get more people interested in optical SETI." He's also showing amateur astronomers they can make a difference.

In fact, Kingsley has been so busy with his promotional efforts, which include maintaining an OSETI website and his full-time day job as head of a photonics consulting firm, he has not had a chance to finish upgrading his telescope and get back to observations, which he's anxious to do. "I get motivated when people say this [OSETI] is rubbish and not worth pursuing," he explains. "Now that others agree it's worth doing, I'm less interested in trying to promote it and more interested in doing it myself."

As a result, Kingsley is considering the possibility of not organizing the next international OSETI conference. It's a lot of work, he says, "and I may not need to do it now that the field is taking off."

Dan Werthimer: A "Nerd at Heart" Leads the Charge

As a high school student in San Francisco during the late 1960s and early 1970s, Dan Werthimer did not join the Pep Club but instead gravitated to the Home Brew Computer Club. While his Home Brew friends — who included Steve Jobs, Steve Wozniak, and occasional club habitue Bill Gates — dreamed about desktop computers, Werthimer thought about how computers might be used in the search for extraterrestrial intelligence, which was a novel idea at the time. Werthimer's compatriots went on to earn their millions and billions; he became a leader in the less lucrative realm of SETI.

After 25 years in the field, he has yet to get rich. Nor has he bagged a single alien. But he pursues the quest with ceaseless vigor and impressive ingenuity. "I'm good at building scientific instruments and designing gadgets," says Werthimer, who moved on from the Home Brew club to the University of California, Berkeley. "My Ph.D. is in physics and astronomy, but like Paul Horowitz, I'm really a nerd at heart."

Werthimer currently directs SERENDIP IV, one of the world's most powerful SETI searches, which is based at Arecibo. Data from this effort is analyzed by more than two million computers distributed around the globe through the "SETI@home" project. He became interested in optical SETI in 1997, noting that "before then, I was so busy with radio, I didn't pay attention to this other idea."

As director of Berkeley's pulsed laser search and an investigator on a similar effort at the Lick Observatory, Werthimer is now convinced that the best strategy in SETI is to try many things. "If I had to pick just one approach, I'd pick radio, but I don't have to do that," he says. Ultimately, we should try to cover as much of the electromagnetic spectrum as possible, he adds. "We need to pursue all kinds of strategies since it's so hard to anticipate what others might do."

Werthimer still finds the search exciting, despite the fact that after roughly 40 years of looking, no one has found a single hint of intelligent life elsewhere in the galaxy. "It would get boring if we kept doing the same thing," he says. "But the technology continues to improve and the searches get better. I don't really expect to be the one to find 'the signal.' But maybe one of my students' students will."

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sky Show

September

A Harvest moon and some sizeable space rocks light up the night.

by Martin Ratcliffe and Alister Ling

► Even if you've been observing the moon for years, new views of it always bring a thrill. The fact remains that our faithful lunar companion is one of the most impressive sights in the sky. No other celestial object lets amateurs follow mountain chains, watch sharp shadows stab across crater floors, and drink in the beauty of the orb's slender crescent backed by earthshine.

As September begins, the last-quarter moon rises late at night and sits high over the southern United States just after sunrise. What a nice opportunity to educate school children about Earth's satellite during a morning class. You can also teach students two weeks later during an afternoon class with a first-quarter moon. On September 21, don't forget to catch the Harvest moon — the naming of which arose in the days before electricity when the moon's orangish glow provided ample light to harvest until well after dusk. As luck would have it, the geometry of the Earth-moon system yields a moon that rises near dusk several nights in a row near full moon in the Northern Hemisphere.

Want to snap a shot of a Harvest Moon suspended over an agricultural landscape? You'll have to shoot before sunset on September 19 or 20, or else just after sunrise on September 21 and 22. If the sun is not above the horizon, the agrarian setting of your choice will likely turn out dark compared to the overexposed moon.

The equinox arrives Sunday night into Monday morning, at 12:55 A.M. EDT on September 23. It's a special day because everyone receives an equal 12-hour day and night. I've heard some radio host mistakenly announce that only people on the equator see the equinox because the sun passes overhead there. Experiment with a flashlight and a spinning globe and you'll see that the equinox occurs for the entire planet when the sun is in line with the equator.

A Harvest moon slowly rises above the Rocky Mountains. William R. Graczyk

If you're sharp-eyed enough, you'll notice that sunrise to sunset time on the equinox is longer than 12 hours. This discrepancy is an artifact — sunrise happens when the top of the sun clears the horizon, and sunset when the last bit of the sun disappears.

Venus's role as evening star in the Northern Hemisphere is waning. Thanks to unfortunate geometry, it's only a few degrees above the southwestern horizon, languishing low in the haze, when it reaches greatest brilliancy on September 26. Observers south of the equator will enjoy it high in the sky along with an excellent view of Mercury. If you have setting circles, you might try for a daytime glimpse of Venus instead.

The early morning sky hogs most of the celestial stage this month. The crescent moon joins Jupiter and the Beehive Cluster (M44) for a gorgeous binocular trio as dawn breaks on September 4. Try challenging your thin moon record: On September 6 from the east coast of North America just a tiny sliver rises only 18 hours before it becomes a new moon. From the west coast, it's only a 15-hour crescent. You'll need a great eastern horizon and very transparent air to succeed.

The best comet of the month (unless we continue to be really lucky) is Wirtanen. This periodic comet punches through the Beehive Cluster on the new moon weekend of September 7. Coincidentally, this is the perfect time to notice the so-called zodiacal pyramid — a large, soft glow of light from solar system dust, which rises in the east before the true dawn begins. To catch this phenomenon, start looking around 4 A.M. local time.

While we're waiting for Saturn to return to the evening sky, set your sights on Uranus, which hovers low in Capricornus. At magnitude 5.7, the planet is just visible to the unaided eye if you know exactly where to look.

2002
September

1 Venus passes 0.9° south of Spica, 2 A.M. EDT
Mercury is at greatest eastern elongation (27°), 6 A.M. EDT
The moon passes 2° north of Saturn, 1 P.M. EDT

4 The moon passes 4° north of Jupiter, 9 A.M. EDT

6 New moon is at 11:10 P.M. EDT

7 The moon is at perigee (222,914 miles from Earth), 11:18 P.M. EDT

8 The moon passes 9° north of Mercury, 1 P.M. EDT

9 The moon passes 8° north of Venus, 10 P.M. EDT

13 First quarter moon is at 2:08 P.M. EDT

14 Asteroid Eunomia is at opposition, 1 A.M. EDT

17 The moon passes 4° south of Neptune, 5 A.M. EDT

18 The moon passes 4° south of Uranus, 2 P.M. EDT

20 Mars is at aphelion (154.9 million miles from the sun), 9 P.M. EDT

21 Full moon is at 9:59 A.M. EDT

22 The moon is at apogee (252,495 miles from Earth), 11:26 P.M. EDT

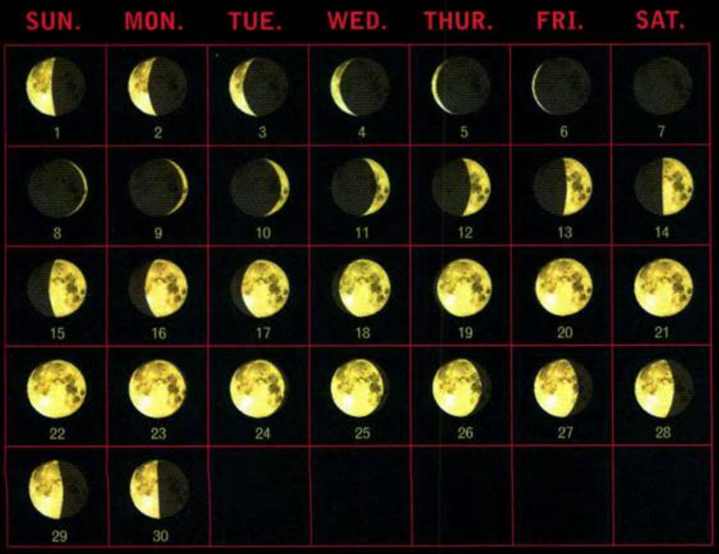
23 Autumnal equinox is at 12:55 A.M. EDT

26 Venus is at greatest brilliancy (magnitude –4.6), 7 A.M. EDT

27 Mercury is in inferior conjunction, 3 P.M. EDT
Asteroid Melpomene is at opposition, 9 P.M. EDT

28 The moon passes 3° north of Saturn, 11 P.M. EDT

29 Last quarter moon is at 1:03 P.M. EDT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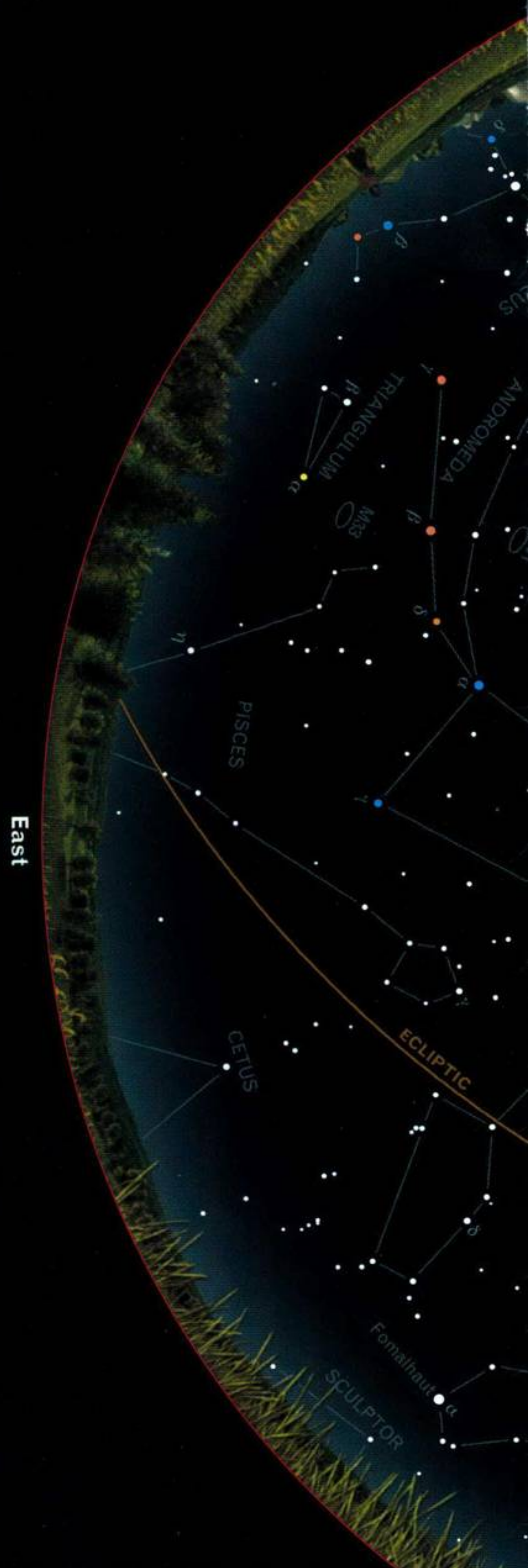
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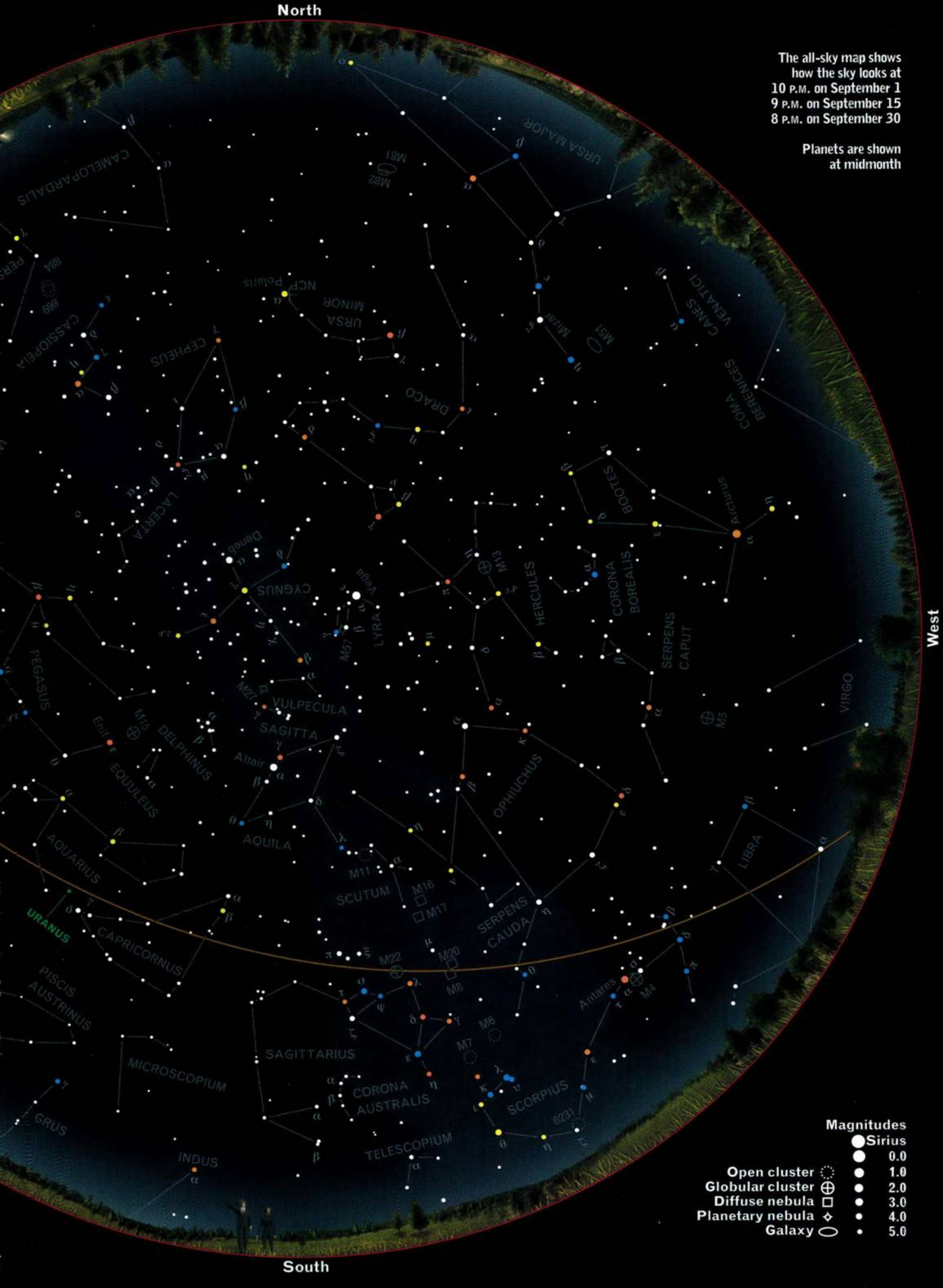
SCULPTOR
Fomalhaut

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
URSA MAJOR
M81
M82
CAMELOPARDALIS
PERSEUS
884
869
NCP
Polaris
URSA MINOR
CASSIOPEIA
CEPHEUS
DRACO
Mizar
M51
CANES VENATICI
COMA BERENICES
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
BOOTES
Arcturus
M13
HERCULES
CORONA BOREALIS
SERPENS CAPUT
PEGASUS
M27
VULPECULA
SAGITTA
Enif
M15
DELPHINUS
EQUULEUS
Altair
AQUILA
OPHIUCHUS
M5
VIRGO
AQUARIUS
M11
SCUTUM
M16
M17
SERPENS CAUDA
LIBRA
URANUS
CAPRICORNUS
M22
M20
M8
Antares
M4
PISCIS AUSTRINUS
M6
M7
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
SCORPIUS
6231
GRUS
TELESCOPIUM
INDUS

The all-sky map shows
how the sky looks at
10 P.M. on September 1
9 P.M. on September 15
8 P.M. on September 30

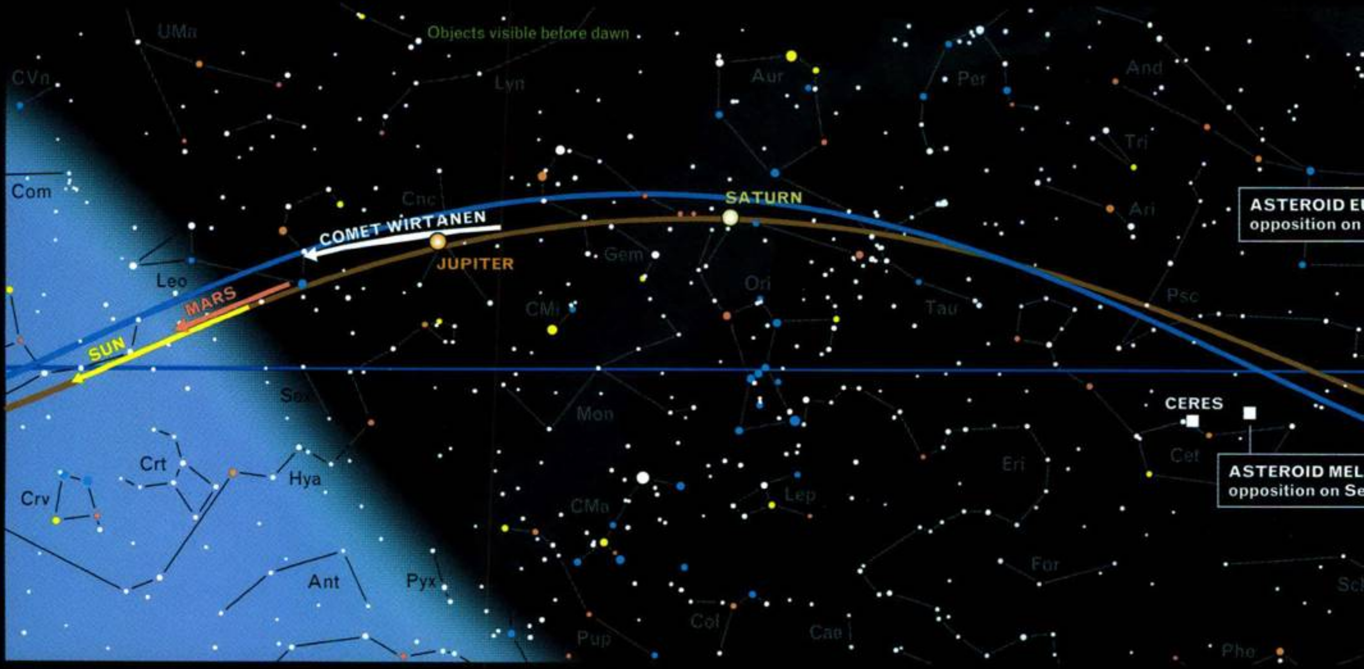
Planets are shown
at midmonth

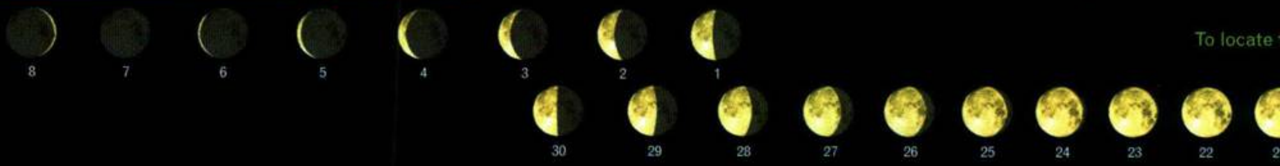
Magnitudes

	⬤ Sirius
	● 0.0
Open cluster ⁙	● 1.0
Globular cluster ⊕	● 2.0
Diffuse nebula □	● 3.0
Planetary nebula ✧	• 4.0
Galaxy ⬭	• 5.0

Path of the Planets

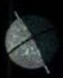
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system object

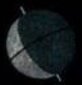

UMa
CVn
Objects visible before dawn
Lyn
Aur
Per
And
Com
Cnc
Tri
Ari
SATURN
ASTEROID E
opposition on
COMET WIRTANEN
JUPITER
Gem
Leo
MARS
Ori
CMi
Tau
Psc
SUN
Sex
Mon
CERES
Crt
Hya
Cet
Eri
Crv
ASTEROID MEL
opposition on Se
Lep
CMa
For
Ant
Pyx
Col
Cae
Pup
Phe
Sc

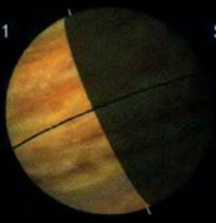

8
7
6
5
4
3
2
1
30
29
28
27
26
25
24
23
22

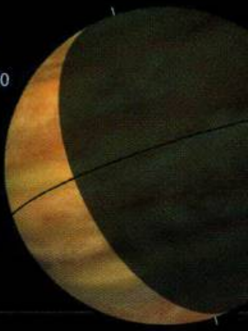
To locate

PLANETS	MERCURY	MERCURY	VENUS	VENUS
Date	September 1	September 15	September 1	September 30
Magnitude	0.2	1.0	−4.4	−4.6
Angular Size	7.1"	9.1"	27.4"	42.1"
Illumination	55%	26%	43%	22%
Distance (AU) from Earth	0.944	0.736	0.609	0.396
Distance (AU) from Sun	0.464	0.420	0.728	0.727
Right Ascension (2000.0)	12h16.5m	12h42.4m	13h24.3m	14h36.1m
Declination (2000.0)	−4°17'	−8°53'	−11°58'	−21°50'



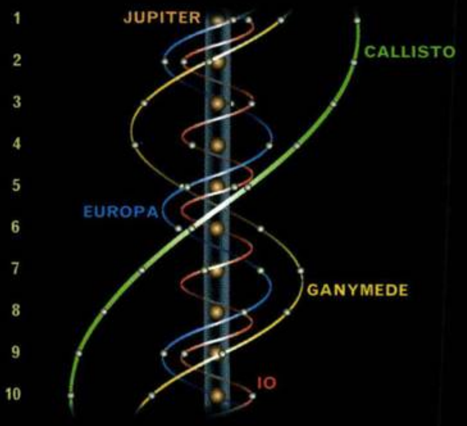


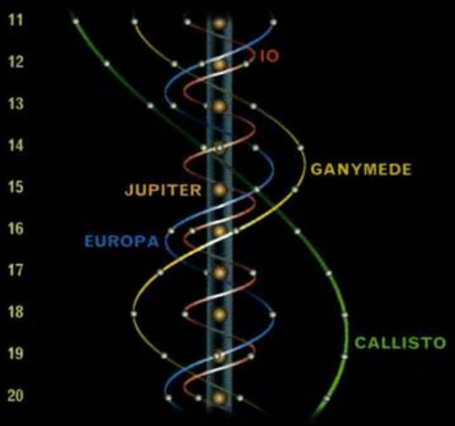


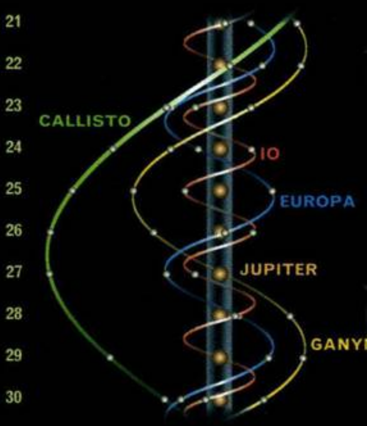


Jupiter's Moons

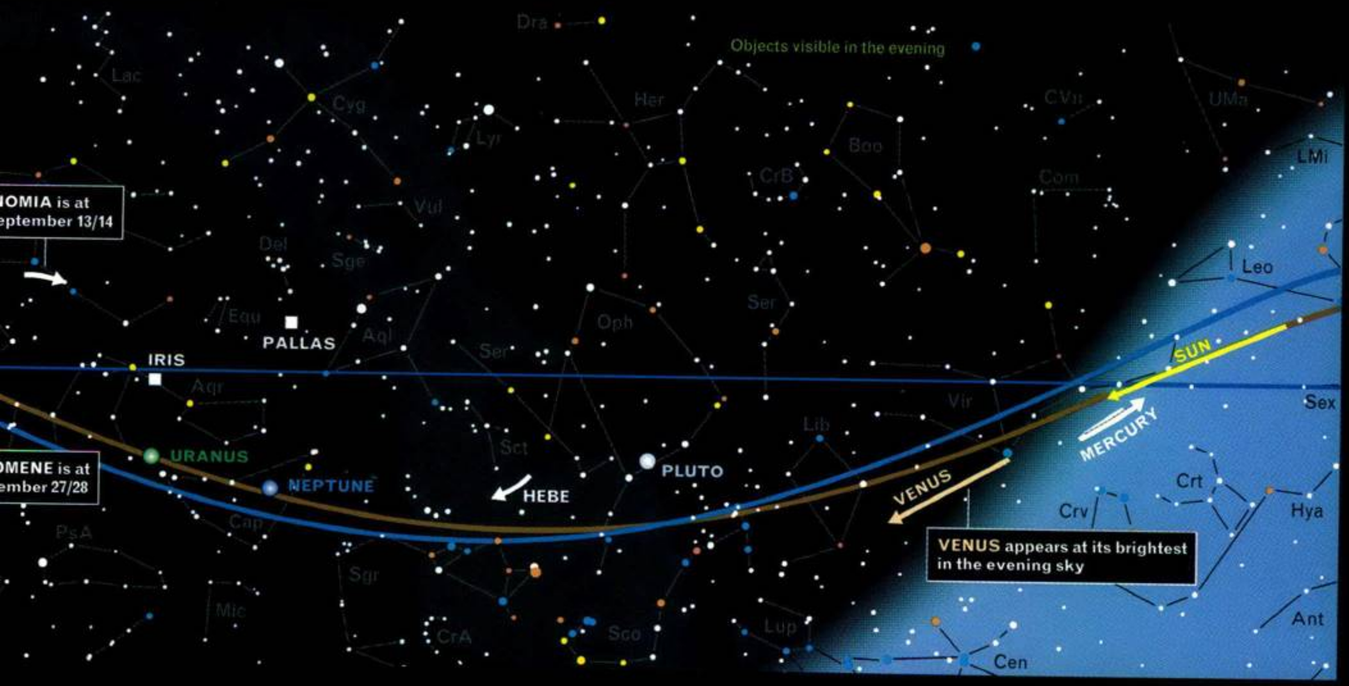
Dots display positions of Galilean satellites at 6 A.M. EDT on date shown. South is at top to match the view in a telescope.







during the month.

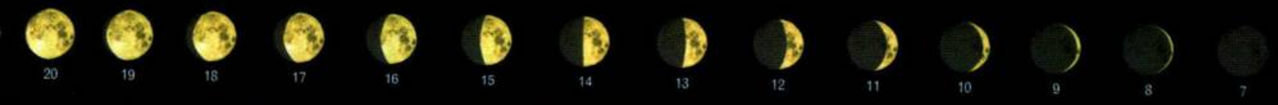

Objects visible in the evening
Dra
Lac
Cyg
Her
Lyr
CVn
UMa
LMi
Boo
CrB
Com
Vul
Del
Sge
Leo
Equ
PALLAS
Aql
Ser
Oph
SUN
IRIS
Aqr
Sex
Vir
MERCURY
Lib
URANUS
Sct
NEPTUNE
PLUTO
HEBE
VENUS
Crt
Crv
Hya
Cap
PsA
Sgr
Mic
CrA
Sco
Lup
Cen
Ant

IOMIA is at
eptember 13/14

OMENE is at
ember 27/28

VENUS appears at its brightest in the evening sky

moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.


20
19
18
17
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14
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12
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10
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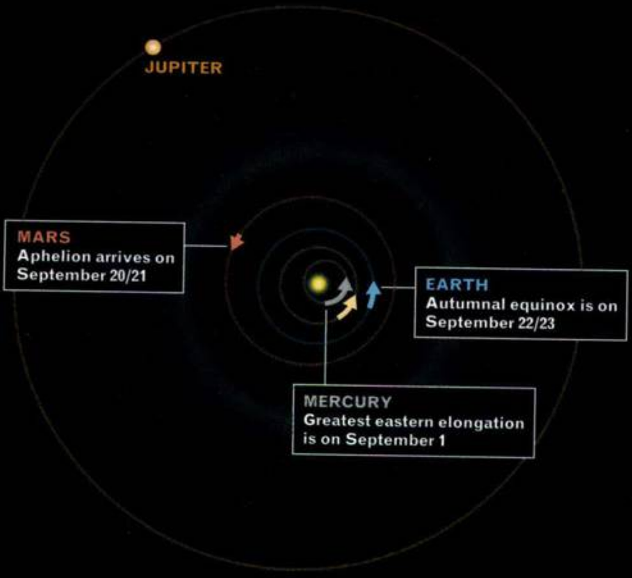
8
7

MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
September 30	September 15	September 15	September 15	September 15	September 15
1.8	–1.9	0.1	5.7	7.9	13.9
3.6"	33.1"	18.3"	3.7"	2.3"	0.1"
99%	100%	100%	100%	100%	100%
2.600	5.959	9.098	19.099	29.350	30.659
1.666	5.265	9.041	20.007	30.088	30.554
11h24.8m	8h47.1m	5h53.1m	21h53.4m	20h43.6m	16h59.1m
5°00'	18°21'	22°08'	–13°38'	–18°05'	–13°02'

The Planets in Their Orbits

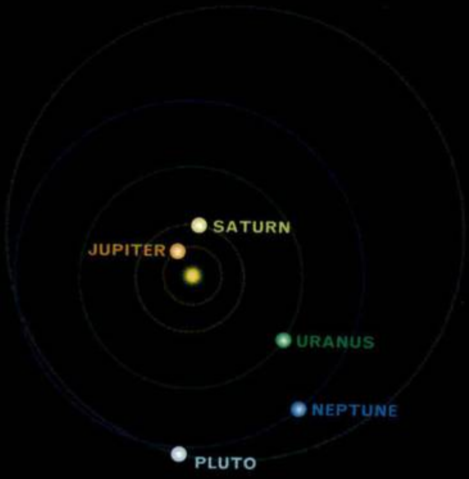
Arrows and dots show planets' positions during the month.



MARS
Aphelion arrives on September 20/21

EARTH
Autumnal equinox is on September 22/23

MERCURY
Greatest eastern elongation is on September 1


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

Doubles in Delphinus the Dolphin

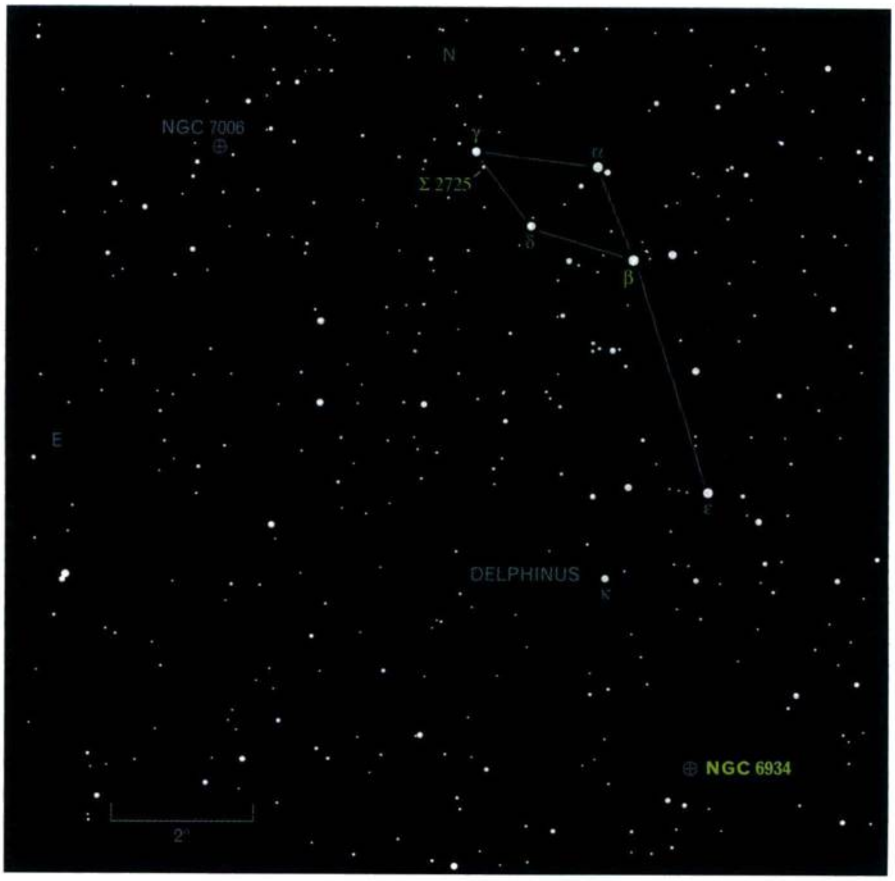
It's little wonder this beautiful grouping of stars was likened to a dolphin leaping out of the water. It's one of the few constellations that actually appears as its namesake. This constellation has been referred to as Delphinus since 400 B.C. across the Mediterranean.

Although there are no Messier objects here to draw the novice's attention, there are certainly some nice sights to see. Make sure you get a steady view of the charming, lozenge-shaped head through binoculars. Your eyes will be immediately drawn to the wide pair at the upper right. Hipparcos satellite data indicate, however, that the two stars are unrelated.

A physically bound pair is but a short hop away. Push up the magnification past 100x in order to split Gamma (γ) Delphini into its two components of magnitudes 4.6 and 5.1, floating about 10" apart. While most observers see both stars in a yellowish hue, several observers have reported a pale greenish hue to the fainter component. Our brain's visual processing system may well be responsible for such a color contrast effect. But even so, it's always neat to see.

While you are in the area, slide 15' (about half a moonwidth) to the southwest. The brightest star in this area is also a binary, Σ2725. According to Richard Dibon-Smith (http://www.dibonsmith.com/orbits.htm), this pair is separated by about 6", almost twice as much as the famous Double-Double pairs in the constellation Lyra.

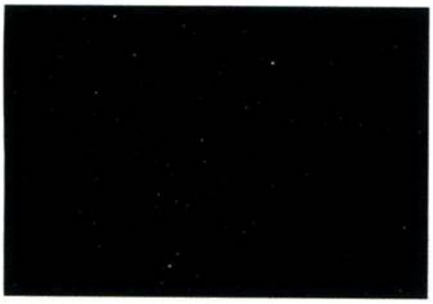
A real challenge awaits those of you who have access to a 6-inch refractor or ultra-sharp 8-inch reflector. Beta (β) Delphini is a close binary pair, a mere 0.6" gap this year. The two stars, magnitude 4.1 and 4.8, are about as far apart as they're going to get in their 27-year orbit.



Reaching much farther out into space, we enter the realm of globular star clusters. With a 4-inch scope from a backyard, you should be able to detect NGC 6934's 8.9-magnitude glow, despite light pollution. Just remember to bring the magnification up past 100x to help darken the background sky. This diffuse round fuzzball is actually brighter than the faintest Messier globular, M72, so it's worth an attempt under less than ideal conditions. A 10-inch or larger scope will partially resolve it and bring its 13.8-magnitude supergiant stars into view.

Don't forget to have a look at this globular between September 9 and 11, when asteroid 2 Pallas slides past only a half moonwidth to the northwest, and then slumps to the southwest.

The other globular cluster in Delphinus is the diminutive and distant NGC 7006. It's half the size of NGC 6934 and glows at magnitude 10.6, but still remains within reach of a 4-inch scope under dark rural skies. Due to the considerable distance of this globular, only a monster scope will pick up its giant stars, which glow feebly at magnitude 15.6. Once thought to roam freely out in intergalactic space, astronomers now think NGC 7006 is firmly in the Milky Way's gravitational grasp. A galaxy like our own often reels in such objects, once ejected by other nearby interacting galaxies.

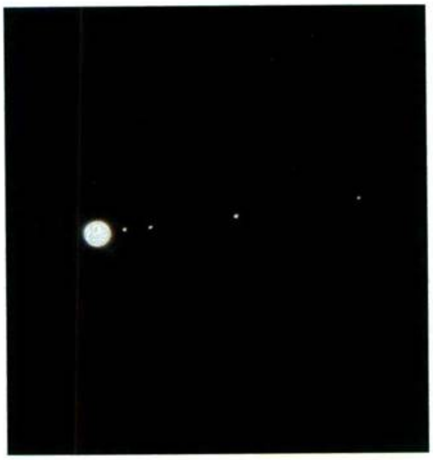


Far left: The summer triangle tightly frames Delphinus the Dolphin. Robert C. Mitchell
Left: The globular star cluster NGC 6934 shines in the belly of the Dolphin. Preston S. Justis

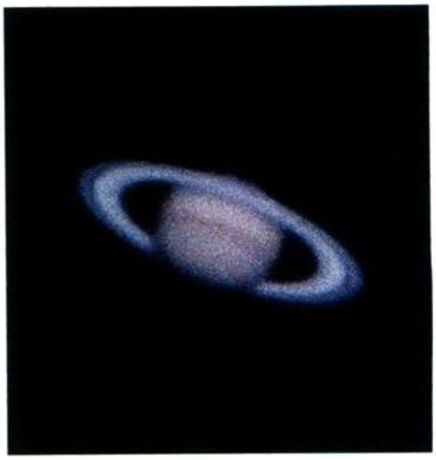
The Evening Star Takes Shape

Venus sits briefly above the southwestern horizon after sunset, where it's the lone planet shining through the twilight evening sky. It reaches its maximum brilliancy of magnitude –4.6 at the end of September. This strong glow places it more than three magnitudes brighter than Sirius, and five magnitudes brighter than its current neighbor in the sky, Spica, which lies in Virgo the Virgin. Venus sets about an hour after the sun this month.

During the past few weeks Venus has been moving toward a position between the sun and Earth referred to as inferior conjunction. It's not there yet, but will reach that point on October 31. Its current location gives us a view of the largely shaded side of the planet. Consequently, telescopic views of Venus reveal a thinning crescent. On September 1, however, Venus shows a 40-percent illuminated disk, which shrinks to 21 percent by the end of the month. This dramatic change in phase allows for remarkably different views of the planet. A fine crescent moon spends a night lingering near our sister planet (see photograph on opposite page) on September 9. The moon complements Venus with a 12-percent illumination during the evening of September 9 in the United States, growing to 21 percent by the following evening.



The Galilean moons together perform an intricate swing dance about Jupiter. Ronald Royer

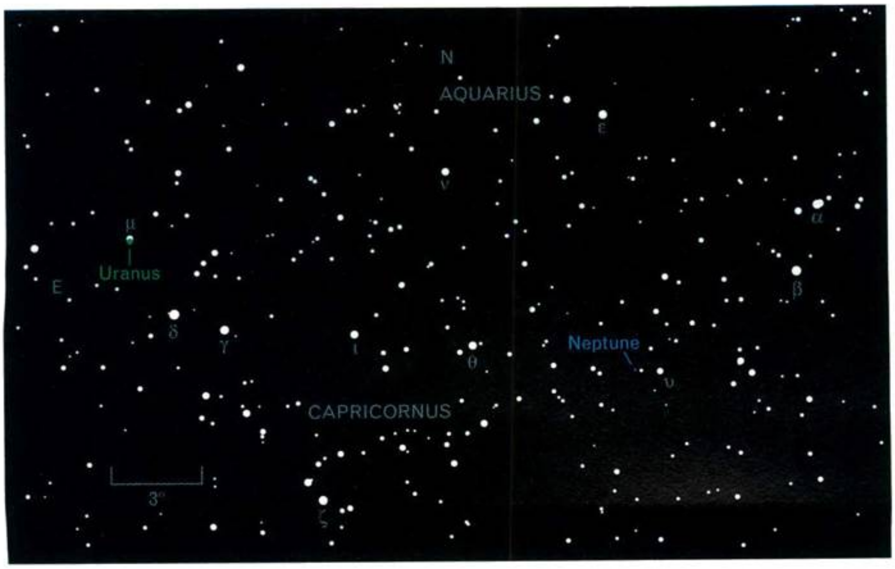


A chance to capture Saturn with exposed rings is a bonus in viewing this planet. Jean Dragesco

Combined with the slimming crescent of Venus is a simultaneous increase in the apparent size of its disk when viewed through a telescope. This observation reveals that Venus's distance from Earth is decreasing. Venus moves approximately 0.2 astronomical unit (18.6 million miles) closer to Earth during September. Consequently, Venus spans 27" as the month opens and grows to 43" thirty days later. However, viewing the planet late in the month becomes increasingly difficult. The low inclination of the ecliptic to the western horizon during autumn evenings places Venus only 8° high at sunset on September 30.

Now we move from the brightest planet to the faintest one. **Pluto** resides in Ophiuchus and glows at a dim magnitude 13.9. This is 18.5 magnitudes, or 25 million times fainter, than Venus. Yet an 8-inch scope can detect Pluto under excellent conditions. Pluto is best found using a highly detailed star atlas and drawings over consecutive nights of the same field of view. Alternatively, CCD camera users can snap an image on two consecutive nights and view each image in rapid succession to capture the interloper. Pluto lies approximately 3.6° northwest of Eta (η) Ophiuchi, although it moves quite low in the southwest just a few hours after sunset.

While **Neptune**, like Pluto, lies in the outer boundaries of our solar system, its substantial globe, five times Earth's diameter, makes it a reasonable target even for binoculars. Neptune is wandering slowly among the faint stars of Capricornus the Sea Goat. It glows at magnitude 7.8, and you can glimpse it near the star Upsilon (υ) Capricorni at magnitude 5.1. Upsilon lies in the western reaches of the constellation, 2.7° east of the more familiar Rho (ρ) Capricorni. You can find Neptune approximately one degree east of Upsilon. A magnitude 7.3 star also lies in a similar location, so take care not to confuse the two. In fact, for a few nights on either side of September 29, Neptune and this faint star near Upsilon appear to form a double star. But if you stay tuned in to this seeming pair from night to night, you'll find that the planet's apparent motion will reveal its true identity.



Uranus lies at the eastern edge of Capricornus, near the border with Aquarius the Water Bearer. Since it shines brighter than Neptune does, at magnitude 5.8, Uranus is easy to pick up in binoculars. A telescope will reveal its tiny greenish-hued disk. To find Uranus, first find Mu (μ) Capricorni, a magnitude 5.1 star that lies exactly 3° northeast of Delta (δ) Capricorni. During the first half of September, Uranus lies due east of Mu, but the planet's westerly motion will carry it closer to this star each night. By September 13 the star and planet appear as a close double. But following this intimate pairing you'll soon see Uranus continue on its westerly way.

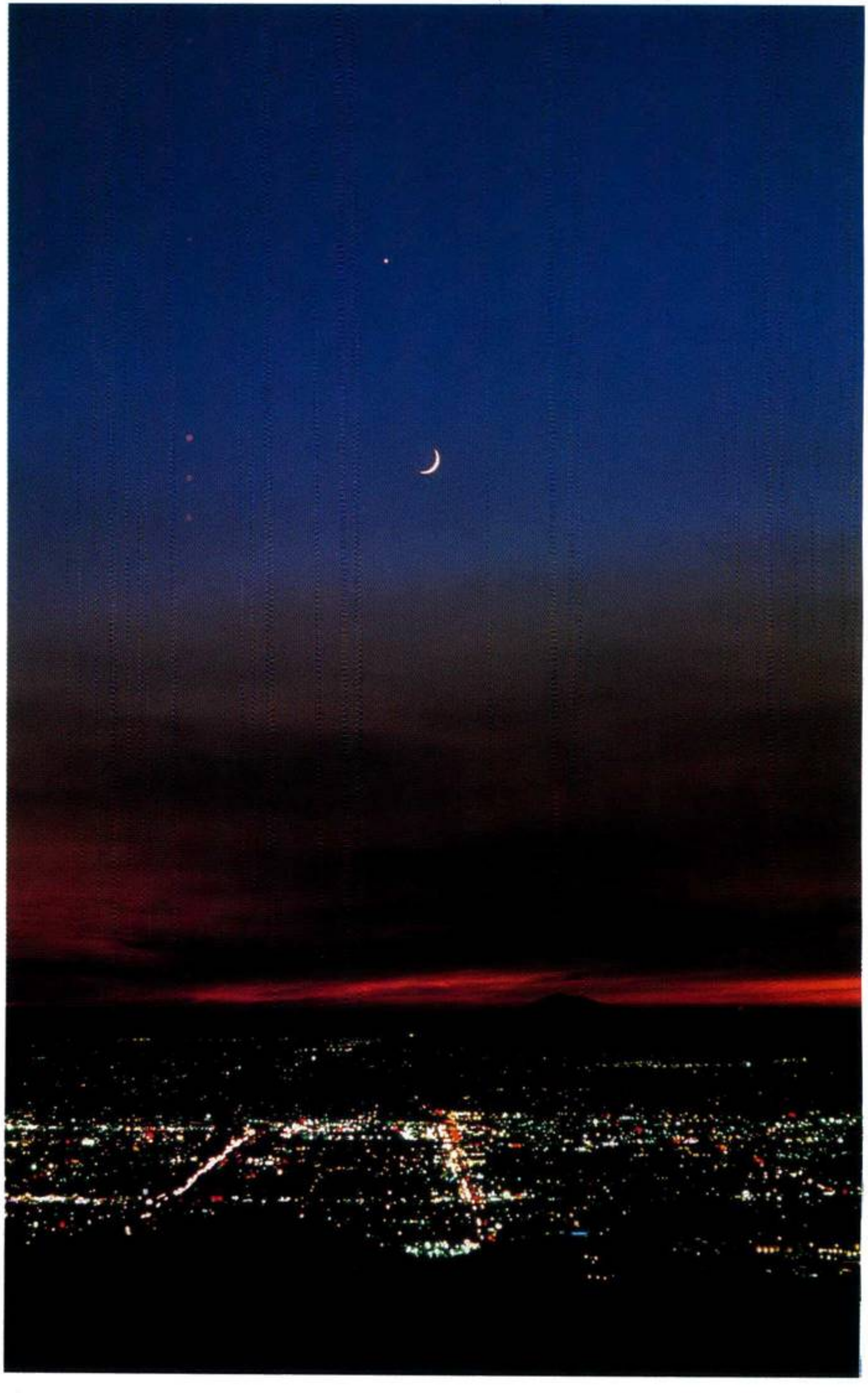
Saturn rises before midnight for most of September, and it remains visible for the rest of the night. The Ringed Planet is very well placed just beyond the western end of Gemini and stands 4° north of the open cluster M35 by the end of the month. Due to its late rising, Saturn is best viewed in the early morning hours once it elevates to a decent altitude. Technically speaking, Saturn spends the entire month soaring through the constellation Orion.

The ecliptic runs very close to the raised eastern arm of Orion and from time to time a planet will wander into that region. While this may be a surprise to some (most students in introductory astronomy courses are taught that our solar system's planets are bound to travel only through the constellations along the ecliptic), Orion is not the only non-ecliptic constellation that planets will wander in to. Pluto currently lies in Ophiuchus, where the ecliptic actually runs through what is the thirteenth constellation. In addition, Cetus the Whale occasionally harbors a planet as the ecliptic runs very close to its borders.

Saturn shines at magnitude 0.1 all month. Its disk spans 17", while the major axis of the rings spans 42". The planet is an outstanding sight in any telescope. A last quarter moon stands 4° northeast of Saturn on the morning of September 29 in the United States.

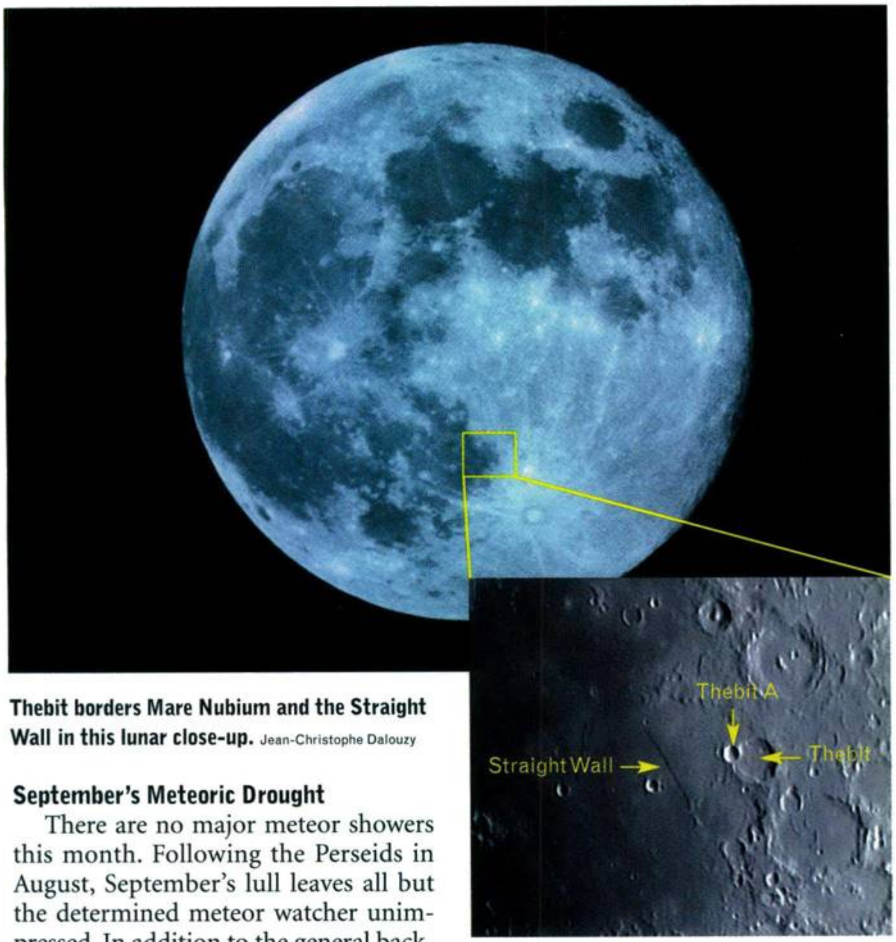
Jupiter rises three hours after Saturn. The giant planet lies in Cancer the Crab. Binoculars will show a splendid sight during the first two weeks of the month, since Jupiter lies only a degree south of M44, the Beehive Cluster. Telescopes from good observing sites should reveal the dance of Jupiter's four major satellites that jockey for position each night. The gas giant's globe is full of fascinating details, most of which will be covered in upcoming months in Sky Show.

Mars passed conjunction with the sun in August and will not be visible for a few months.



Venus and a crescent moon pair up in shining over El Cajon, California, at sunset. Jerry Schad

Meteors and Moons



Thebit borders Mare Nubium and the Straight Wall in this lunar close-up. Jean-Christophe Dalouzy

September's Meteoric Drought

There are no major meteor showers this month. Following the Perseids in August, September's lull leaves all but the determined meteor watcher unimpressed. In addition to the general background of random or sporadic meteors, which can reach up to seven meteors per hour, there are minor showers that may produce activity. These minor showers are not at all well observed, so data on them is sparse. The Alpha Aurigids and Piscids are affected by moonlight this month. The Delta Aurigids have an uncertain peak around mid-September, with activity spanning from September 5 to October 10. Multiple radiants are suspected. Meteors from this shower are usually faint, though bright meteors and associated trains have been observed. Catching one of these rare meteors might be as thrilling as seeing a Perseid.

Locking on to a Chain

The crater Thebit lies north of the ancient chain of craters that includes Regiomontanus, Purbach, and Walter. The first- and last-quarter moon is the best time to catch this 34-mile (54-km) wide crater and its surroundings in the lunar highlands. It's the most prominent crater of the series, and just to its west you'll find the famous Straight Wall. The days following sunrise on Thebit will reveal details of the rough crater floor with no central peak. The larger and older craters to its north do have central peaks, a feature that accompanies many larger craters. The northwestern rim of Thebit has been breached by a 12-mile-wide crater, Thebit A. This crater itself has a smaller crater, Thebit L, on its western flank, which on close inspection appears older than Thebit A. The rough terrain around Thebit gives way to the smoother floor of Mare Nubium, pitted with tiny craters. Near first quarter as the sun rises over the crater its shadows often stretch across this small plain. Southwest of Thebit lies the remains of an ancient crater largely smothered by lava from Mare Nubium.

Callisto Events for September 2002

	UT	EDT	
Sept. 5	17:19	1:19 P.M.	IV.Sh.I.
	21:47	5:47 P.M.	IV.Sh.E.
		8:21 P.M.	IV.Tr.I.
Sept. 6	00:21		IV.Tr.I.*
	04:57	12:57 A.M.	IV.Tr.E.
Sept. 13		8:46 P.M.	IV.Ec.D.
Sept. 14	00:46		IV.Ec.D.*
	05:21	1:21A.M.	IV.Ec.R.
	09:01	5:01 A.M.	IV.Oc.D.
	13:45	9:45 A.M.	IV.Oc.R.
Sept. 22	11:18	7:18 A.M.	IV.Sh.I.
	15:49	11:49 A.M.	IV.Sh.E.
	20:20	4:20 P.M.	IV.Tr.I.
		9:01 P.M.	IV.Tr.E.
Sept. 23	01:01		IV.Tr.E.*
Sept. 30	18:46	2:46 P.M.	IV.Ec.D.
	23:24	7:24 P.M.	IV.Ec.R.
Oct. 1	04:52	00:52 A.M.	IV.Oc.D.
	09:41	5:41 A.M.	IV.Oc.R.

Jupiter's Satellites

Jupiter's reappearance marks the return of tracking occultations, eclipses, and transits involving the outer Galilean moon Callisto. During each 12-year orbit of Jupiter around the sun, only two series of eclipses involving Callisto occur. The current series began in late 2001 and continues until September 2004. Only 66 eclipses will occur in this time frame. The events listed in the adjacent table are given in Universal Time (Greenwich Mean Time) and Eastern Daylight Time. Events that occur on either side of midnight are shown twice*, since the date changes for observers in Europe or the USA. Tr = transit; I = Ingress; E = Egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their rarity.

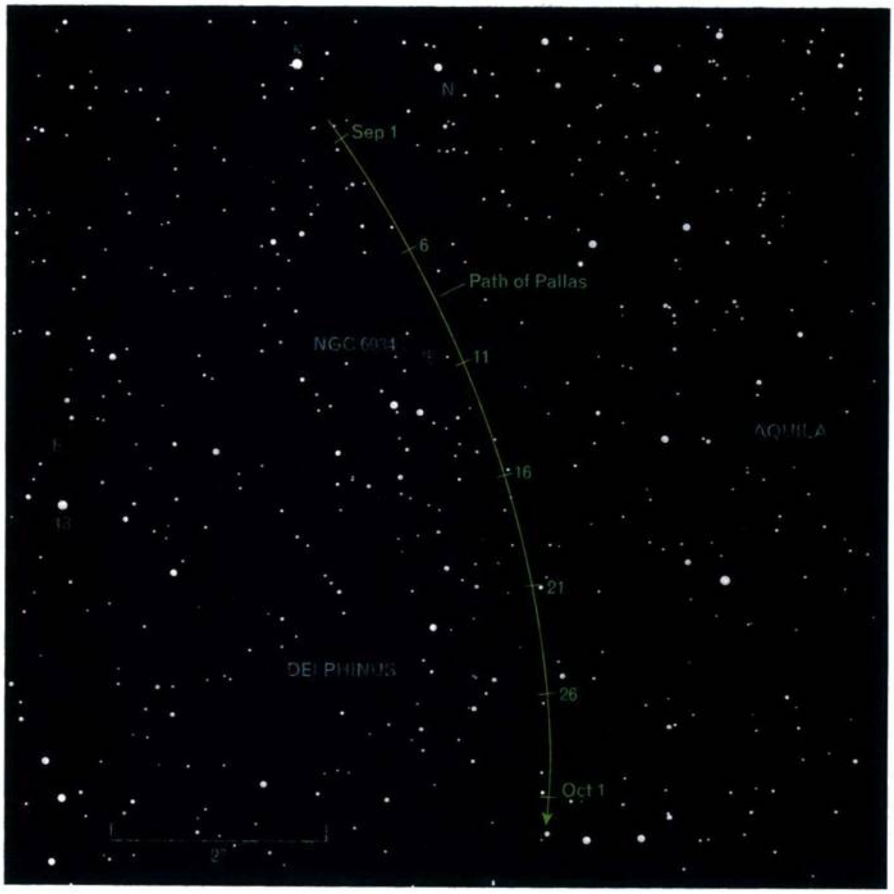
Pallas Grazes a Globular

The rocky rubble of the solar system generally orbits the sun on the same playing field as the rest of the planets, what astronomers call the ecliptic plane. But Pallas, the second asteroid ever discovered, is inclined differently from the vast majority.

This month, the 9.5-magnitude space rock is sharing the waters of Delphinus, the celestial dolphin. It lies just east of the Aquila Milky Way near the middle of the fold-out chart. With any backyard scope you should easily track Pallas as it "swims" for a few nights across the small constellation. Begin your star hop at Kappa (κ) Delphini, and Pallas is only 1° (two apparent moonwidths) away at the start of the month.

One of the highlights of the month comes on the nights of September 9 through 11 when the huge space rock comes within half a moonwidth of the globular star cluster NGC 6934.

So just how much does Pallas's orbit veer off the beaten path? Most main belt asteroids rise and fall within 2 to 8° of the ecliptic. Pallas is inclined 35° off, unusual in itself, but more impressive because it is one of the "Big Four" asteroids along with Ceres, Vesta, and Juno.

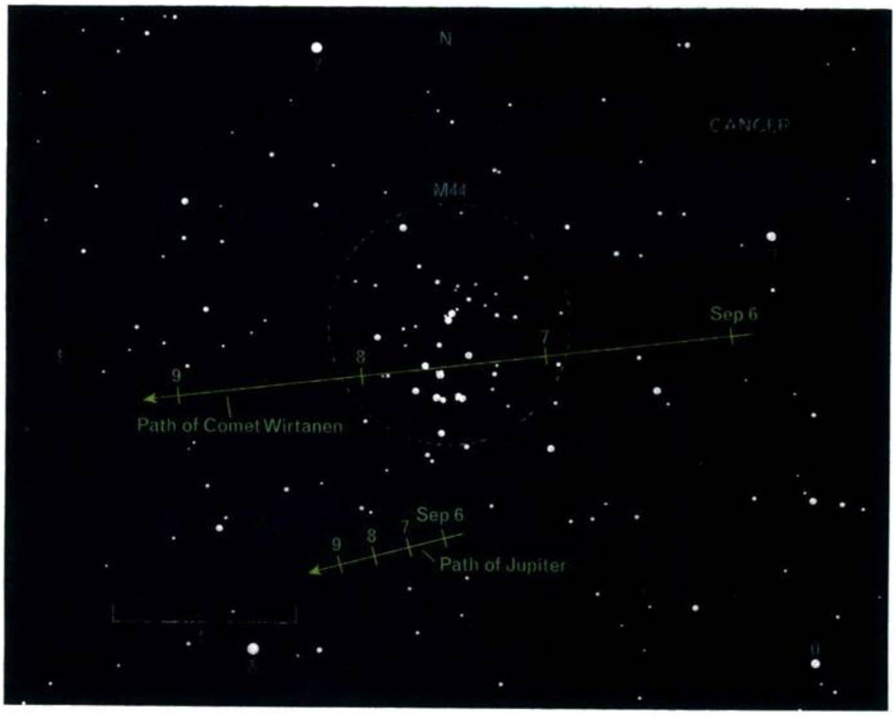


Watching Wirtanen

If you can spot Jupiter in the predawn sky, you'll land in the right zone for seeing comet Wirtanen. Only 1° from Jupiter lies the large sparkling Beehive Cluster, (M44). A small scope should show both in the same field.

By Sunday morning, September 8, Wirtanen lies just to the east of the V-shaped group in the heart of M44.

If you have a 12-inch scope or larger try and locate NGC 2624, the brightest of a handful of tiny galaxies in the distant background of the Beehive Cluster. At magnitude 14.1, it should offer quite an observing challenge since it's only 15° to 20° above the eastern horizon as astronomical twilight intrudes. **A**



Martin Ratcliffe is President of the International Planetarium Society. Alister Ling is a meteorologist working for Environment Canada.

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ETX-125EC

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If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who can help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***. Experienced? One of us got his first scope in 1952, another got his in 1955!

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Celestron, Discovery, Meade, Questar, Stellarvue, Takahashi, TeleVue, and TMB scopes we stock. And we can usually ship the right scope right away, since we have over 1000 scopes in stock!

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"Optics as good as I have seen . . . in any telescope . . . at any price."

A review in June's *Sky & Telescope* said the **TMB 100** 4" f/8 ED triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price." It just confirms what dozens of our very satisfied customers have been saying about their TMB apo refractors for months.

TMB 100

Not only do the TMB ED apo refractors have optically unsurpassed triplet optics and precision mechanics (such as a 3" focuser), but many of the sizes listed below are available from stock. Even those that may be temporarily out of stock are usually available again in few short months, not a few years, as is the case with another well-known brand.

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TMB 80/6 80mm (3.1") f/6	**\$1690^{00}**
TMB 80/7 80mm (3.1") f/7	**1690^{00}**
TMB 100 100mm (4") f/8	**3290^{00}**
TMB 105 105mm (4.1") f/6.2	**3290^{00}**
TMB 152 152mm (6") f/7.9	**6990^{00}**
TMB 175 175mm (7") f/8	**11,990^{00}**
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For more information, or to discuss specific pricing, contact Pete via e-mail care of questions@astronomics.com. You can also reach him by phone toll-free from 9 to 5 Monday through Friday at (800) 422-7876.

The Meade LXD55 makes ordinary reflectors and refractors obsolete.

Meade 5" LXD55 refractor
$695

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Meade 8" LXD55 f/4 reflector
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TV-102, optical tube only	**2200^{00}**
TV-85, standard package	**2080^{00}**
TV-85, optical tube only	**1680^{00}**
TV-76, standard package	**1675^{00}**
TV-76, optical tube only	**1275^{00}**
Pronto, standard package	**1120^{00}**
Pronto, optical tube only	**775^{00}**
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NP-101 **$3385**

TV-85 **$2080**

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From 5.2mm to 40mm, we stock all of the Pentax wide field (55° to 65°) XL eyepieces. Each has a rotate-to-adjust-the-eye-relief eyecup, ED glass for exceptional edge to edge sharpness, and a long 20mm eye relief that's perfect for those who wear eyeglasses.

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10.5, 14, 21, or 28mm 1.25"	**227^{50}**
40mm 2"	**244^{50}**
8-24mm zoom 1.25"	**379^{00}**

The Stellarvue refractor, "Hot New Product of 2001."

The 80mm f/6 **Stellarvue AT1010** was named a "Hot New Product of 2001" in the December 2001 *Sky & Telescope*. Independent reviews say it competes favorably with ED scopes that cost twice its modest price, and easily outperforms imported achromats in color correction and resolution. The AT1010A has hand-assembled/triple tested optics, tube rings, tripod adapter, 2" focuser with both 1.25" adapter and T-threads, red dot finder, oversize rubberized focus knobs for easier use in cold weather, and a soft padded carry case. It's in stock to ship now.

AT1010A **\$499^{95}** shown w/optional diagonal and eyepiece

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$1695

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8" and 10" Meade GPS UHTC scopes ship from stock. They do all of the work so you can see 20% more.

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8" LX200
GPS
with
UHTC
$2670

Never before have so many features been packed into one telescope series. The new LX200GPS scopes – the widest variety of premium go-to telescopes on Earth – have all the features you've dreamed about since you started astronomy – plus optional UHTC (Ultra High Transmission Coatings) for up to 20% brighter images.

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Meade GPS scopes with UHTC optics will let you see up to 20% *more.* Plus, you'll spend more time looking *at* celestial objects and less time looking *for* them. We had 39 8" and 10" LX200GPS scopes with UHTC in stock as this was written. Chances are good we have one in stock for you.

An ETX-90 case, $74⁹⁵!

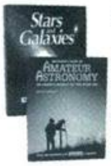
The 8" x 15.5" x 18.5" JMI hard case fits the ETX-90RA and the ETX-90EC. Its high density foam interior is diecut to hold scope, four eyepieces, tabletop tripod, T-adapter, and more. Whether for storage or travel, this hard case is a great buy. Regularly $99.95, we have less than 50 still available at this low sale price that saves you 25%.

We also have cases available for the Meade LX90 and 8" through 12" LX200GPS, and the Celestron NexStar 4/5/8 and 8/11 GPS.

Canon image-stabilized binoculars . . . a whole lot less shaking going on!

"Truly a quantum leap in binocular observing . . . particularly impressive was how well these binoculars compared to much larger apertures . . . " is what *Sky & Telescope* said about the Canon image-stabilized binoculars. There are no jittery images while hand-holding these binos, just rock-solid observing that reveals more detail than conventional binoculars. From a tiny 8 x 25mm for travel and birding to a big 18 x 50mm that's excellent for astronomy, there's an image-stabilized Canon that's right for you – and a new lower price from Canon. You'll find full details on our website.

Half-price sale on observing books!



We bought almost 4000 beginning and advanced deep space observing books at some very special prices. We're passing our savings on to you, pricing them as low as 50% off retail. Take a look . . .

Beginner's Guide to Amateur Astronomy 166 page soft cover, a great way to start, reg. $14.95	**$9⁹⁵**
Galaxies & The Universe 112 page soft cover, helps you find 100s of galaxies, reg. $19.95	**$9⁹⁵**
Stars & Galaxies 200 page hard cover, observe 344 of the best deep sky objects, reg. $29.95	**$14⁹⁵**
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> **Customer Quote of the Month #125**

Eyepiece storage cases from $249.

Bolt-type containers protect eyepieces dew and dust. Foam inserts cradle eyepieces to protect them from accidents. Our website tells which eyepieces fit in which containers (including some other containers that are not listed below).

42mm x 60mm Holds most Celestron NexStar, Meade Series 3000, and TeleVue Plössls, etc.	**$2⁴⁹**
52mm x 80mm Holds TeleVue Radians, Nagler Type 6, most Barlows, large Celestron Ultima, etc.	**$3⁴⁹**
65mm x 80mm Holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	**$3⁹⁹**

The rave review multicoated NexStar 11 can be yours in a week.

NexStar
11 GPS
$2999

Celestron's 11" go-to computerized scope with multicoated optics – the **NexStar 11 GPS** – got a *rave* review in February's *Sky & Telescope.* The review gave it "an enthusiastic two thumbs up and a gold star." They said it has "Brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

We have the NexStar 11 in stock (16 as this was written). Call us and you can be observing with yours in about a week.

The NexStar 8 GPS is multicoated for both CCD and visual observing.

NexStar 8 GPS **$2499**

The in-stock 8" **NexStar 8 GPS** (17 on hand as this was written) has Starbright high transmission multicoated optics for brighter images at no extra cost. You can easily convert its unique Fastar optics to a blazingly fast f/1.9 focal ratio for wide field CCD imaging.

With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the NexStar 8 GPS records a huge 32 x 42 arc minute field – larger than the full Moon and over three times the sky area imaged by a $7695 camera on other 8" scopes without Fastar! Of all GPS scopes, *only Celestron NexStars have multicoated Fastar optics!*

New Celestron Modular i Series 8" GPS SCTs Starting at $1199!!!

Compare the price of the **New Celestron NexStar 8i** go-to SCT with other 8" go-to scopes. Starting at only $1199 you can add options that you, and your budget, feels comfortable with. Options include the iCOMP computer hand control with over 40,000 objects in its database for only $149. There are two tripod choices as well, the light weight travel model at $149, or the heavy duty tripod, like the NexStar 11 GPS uses, at $299. If you would like the convenience of a GPS model you can add that for $199. However you chose to outfit your telescope, it will be enough scope to keep you observing for the rest of your life, at a price that puts 8" go-to astronomy just about everyone's reach.

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Or $899 for the only 5" GPS available.

The **New Celestron NexStar 5i** is the first telescope to have a fully automatic GPS (Global Positioning System) go-to computer capability. No other 5" telescope has an available GPS system! Even better, the modular nature of the NexStar 5i means that you can build up to a fully automatic GPS system gradually, as your budget allows. NASA uses 5" Celestron multicoated optics on the Space Shuttle. Don't your eyes deserve the same quality?

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A $450 bino for only $17995? One couple bought 9!

Free $7.95 Nikon lens cleaning pen with purchase

One couple liked the two $450 list **Celestron/Tasco 8 x 42mm Rare Bird** roof prisms they bought from us so much that they bought seven more to give to their kids!

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Discovery Dobsonian reflectors start at only $339.

Why settle for an imported Dob when you can have made-in-the-USA quality *for less money!* Discovery doesn't use imported, mass-produced optics that are merely spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each DHQ series Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a dust cover. You can get an upgrade kit that adds two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter for only $49 more!

Premium Dobs from 10" to 17.5" in aperture are also available. And for those who need big aperture portability, truss-tube Dobs are available in apertures from 12" to 24". Here are the Discovery 6" to 10" DHQ Dob prices:

6" f/5 Discovery DHQ	**$339⁰⁰**	plus $49 freight
6" f/8 Discovery DHQ	**$339⁰⁰**	plus $49 freight
8" f/6 Discovery DHQ	**$449⁰⁰**	plus $49 freight
8" f/7 Discovery DHQ	**$449⁰⁰**	plus $49 freight
10" f/4.5 Discovery DHQ	**$649⁰⁰**	plus $69 freight
10" f/5.6 Discovery DHQ	**$649⁰⁰**	plus $69 freight

A $7995 cure for the refractor blues!

The **Sirius MV1-1** eyepiece filter reduces the annoying violet halos around bright objects in inexpensive achromatic refractors. *Sky & Telescope* said, "it will improve the view, especially of the Moon and planets."

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The Brightest of All, Planets as Slingshots, Milky Way Globulars

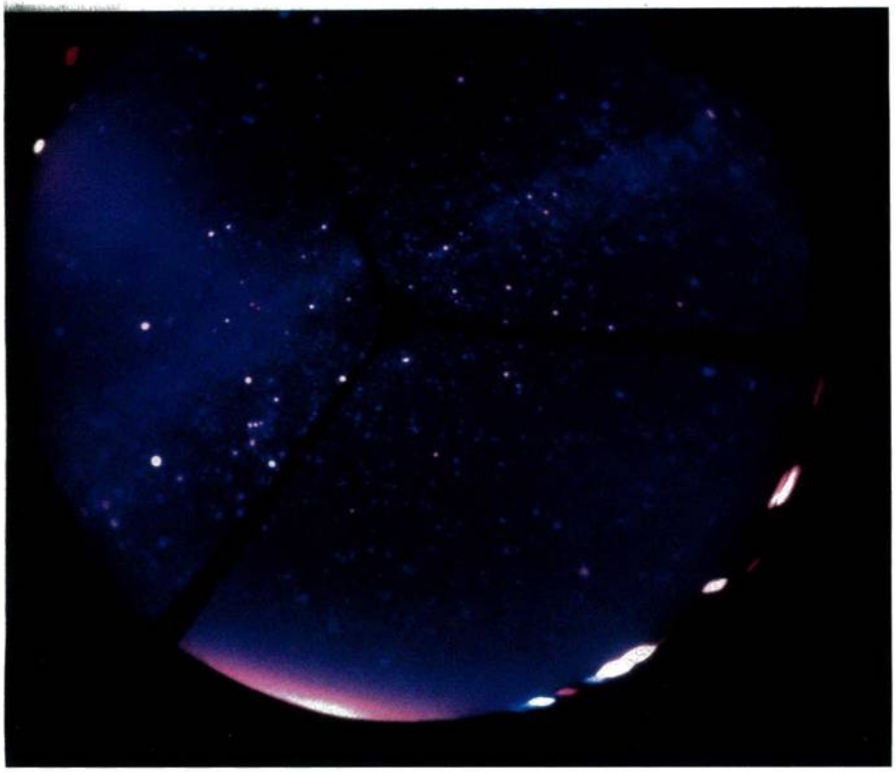
If all the naked-eye objects outside the solar system and visible in one hemisphere of the night sky under optimal conditions were gathered together as one object, how bright would it be? — *Scott Holder, Midway City, California*

Not as bright as you might think. It's tempting to believe that the firepower of all the deep-sky objects visible on an inky black night from, say, the summit of Mauna Kea would be close to overwhelming. Not as bright as the sun or moon, of course — after all, night does not turn to day — but shouldn't they at least put the planets to shame?

Not quite. The key point is that it takes a lot of faint objects to add up to a single bright one. To arrive at an approximate answer, we need to make a few assumptions. First, we'll assume that the faintest naked-eye stars glow at magnitude 6.5 (a good estimate for middle-aged eyes from a dark site). We'll also assume that the atmosphere does not dim stars, so that a star just above the horizon appears as bright as it would at the zenith. Finally, we'll calculate the combined brightness of all the naked-eye stars and divide that result by two to get the answer for one hemisphere.

If we add the 21 stars brighter than magnitude 1.5 (from Sirius at –1.46 to Regulus at 1.35), they combine to a –3.09-magnitude star. If we then assume that all 71 2nd-magnitude stars (those between magnitudes 1.50 and 2.49) can be approximated by 71 stars of magnitude 2.00, they sum to magnitude –2.63. This should yield a good estimate because, even though the brighter stars would have a disproportionate effect, there are more fainter ones.

Adding all the naked-eye stars together would give an object no brighter than Venus. Chris Schur



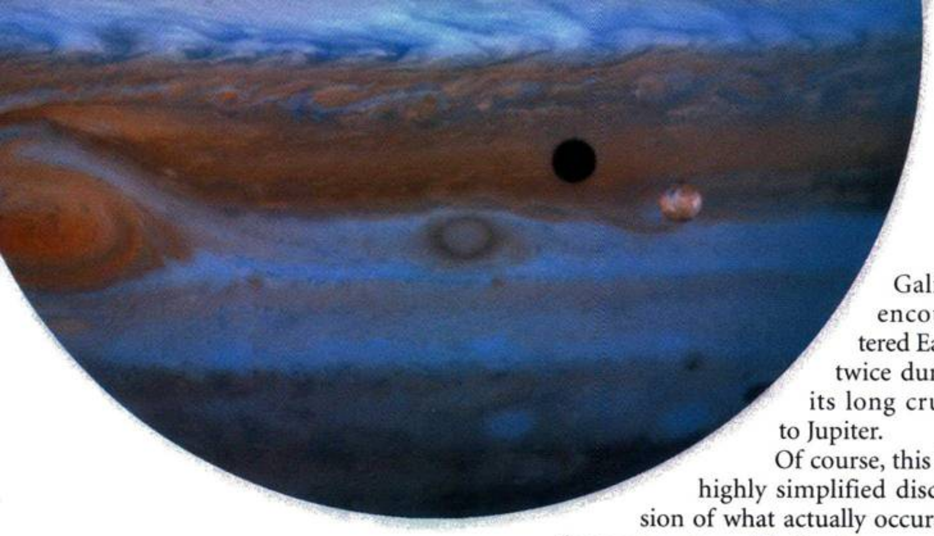
Adopting the same approach for the 192 3rd-magnitude stars, 625 4th-magnitude stars, 1,963 5th-magnitude stars, and 5,606 6th-magnitude stars gives a total brightness for the nearly 8,500 stars of magnitude –4.98. If we then restrict this to one hemisphere, the brightness falls to a magnitude of –4.23. Although that's bright, it wouldn't beat Venus at its brightest magnitude of –4.7.

Adding in extended deep-sky objects would have little effect. Even the brightest nebulae and galaxies shine with positive magnitudes, and there are so few of them that they would add little to the total. And bright star clusters like the Pleiades are dominated by naked-eye stars that we already included in our count. — *Richard Talcott, senior editor*

Spacecraft often use flybys of the planets to boost their speed. How is it that gravity seems to have such a one-way effect? If a spacecraft falls toward a planet, it picks up speed. Why doesn't gravity slow the spacecraft equally as it heads away from the planet? — *Mike Casmey, North Plymouth, Minnesota*

I find that many people are confused by the process that allows a spacecraft to gain or lose energy when it encounters a planet. Yet the principles involved are nothing more than the conservation laws embodied in Newton's laws of motion. The confusion stems from thinking about the problem in a planet-centered coordinate system — the spacecraft approaches the planet with one speed and leaves with a similar speed but in another direction. Because the approach and recession speeds are essentially equal it appears that energy is approximately conserved even though the spacecraft's momentum has changed dramatically. The kinetic energy of the spacecraft is proportional to the square of its speed and the momentum depends on the direction of motion as well as the speed.

However, kinetic energy is a relative quantity and things appear different if



Cassini gained an energy boost when it flew past Jupiter in 2000. NASA/JPL/University of Arizona

you look at this interaction from the point of view of an observer located at the sun. And that's the correct way to consider these things because the sun's overwhelming gravity determines both the orbits of the planets and the interplanetary spacecraft moving among them. It is in this coordinate system that energies and momenta need to be calculated. Think of a spacecraft approaching a planet with a speed V in the direction of the orbital motion of the planet, which is moving with speed VP. Then from the sun it would appear that the spacecraft has a speed VP+V.

Now let's assume that the spacecraft passes very close to the planet and its gravity changes the direction of the spacecraft by 180°. Although not possible in practice — the spacecraft would have to pass *through* the planet — it serves to illustrate the principle. Because the planet's mass is so much greater than the spacecraft's, the spacecraft leaves the planet at the same speed V but now in the direction opposite to the planet's motion (which is barely affected). So, as seen by our observer on the sun, the spacecraft's speed drops to VP–V. Since kinetic energy depends on the square of the speed, the decrease in energy is proportional to (VP+V)^2 – (VP–V)^2, or 4xVPxV. This represents a substantial change in orbital energy and would put the spacecraft on an orbit that would pass much closer to the sun than the original orbit.

If we had assumed instead that the planet overtook the spacecraft rather than the reverse, we would have found that the spacecraft gained orbital kinetic energy and was thrown on to an orbit that would have moved it out from the sun. This was what happened when Galileo encountered Earth twice during its long cruise to Jupiter.

Of course, this is a highly simplified discussion of what actually occurs in these encounters. Timing is supremely important and changes in both energy and momentum must be accounted for. Another issue is arriving at the destination planet with a minimum of relative orbital kinetic energy. Also, these orbital transfers can often be tailored by firing thrusters during the time of encounter. The important point to remember is that kinetic energy is a relative quantity and its value depends on the coordinate system in which it is calculated. — *Michael J. S. Belton, President, Belton Space Exploration Initiatives, LLC. He is the Imaging Science Team Leader for NASA's Galileo project and deputy principal investigator for both the CONTOUR and Deep Impact projects.*

How many globular star clusters exist in the Milky Way? — *Clifford Fivre, Everett, Massachusetts*

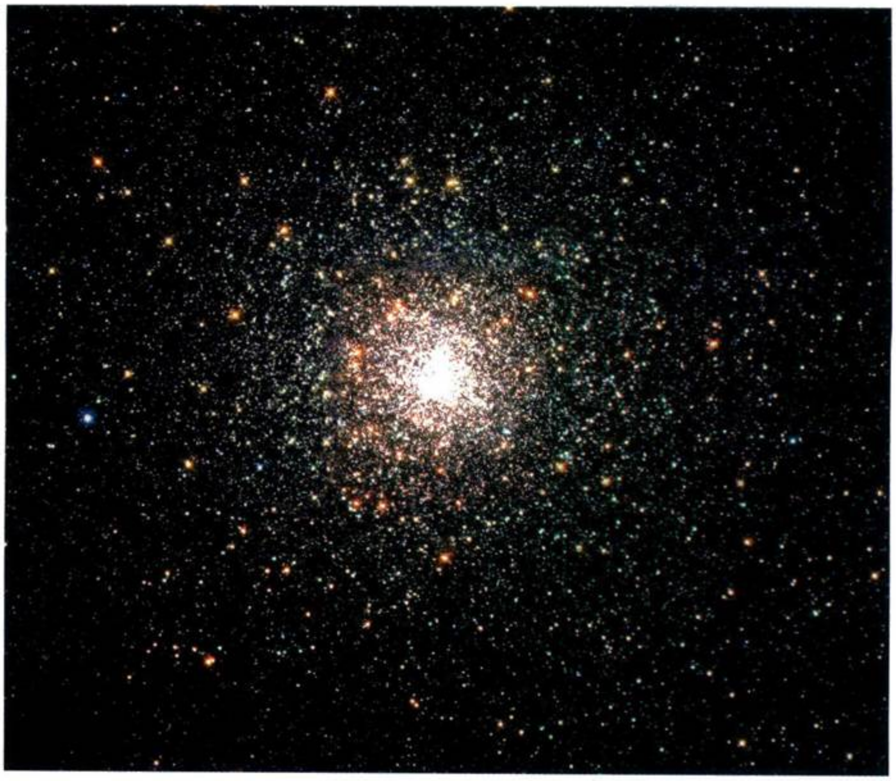
The latest count pegs the number at 147. The brightest lies in the southern sky: Omega Centauri shines at magnitude 3.7. It also ranks as the most luminous, radiating a million times the light of our sun. The honor for the closest globular goes to M4 in Scorpius, a stone's throw away at 7,200 light-years. At the other extreme, Arp-Madore 1 lies 400,000 light-years away — more than twice as far as the Milky Way's brightest satellite galaxy, the Large Magellanic Cloud.

In the early 20th century, globulars played the key role in learning the size of the Milky Way and Earth's place in it. Harlow Shapley mapped the distribution of globulars and discovered that they formed a sphere centered not on the sun but on a spot in Sagittarius some 30,000 light-years away. He made a bold — and accurate — assumption that this was the center of the galaxy. — *R. T.*

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live.

M80 is one of 147 globular clusters in the Milky Way. The Hubble Heritage Team (AURA/STScI/NASA)



Have Scope Will Travel

The Tele Vue 76 offers quality views with easy transport.

by David Healy

The Tele Vue 76 is Al Nagler's newest entry in a long line of high-quality refractor telescopes. It offers quality views and ease of transport for those who must travel to their favorite dark-sky observing site. Just remember to pack your favorite equatorial mount, as the unit is sold separately from any accessories. But if excellence in a small package is your goal, the Tele Vue 76 may be the scope for you.

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MADE IN W.-GERMANY

A Hands-On Survey

I recently put a Tele Vue 76 (TV 76) scope through its paces under Arizona's autumn and winter skies. Early on I decided that operating this instrument on a photographic tripod was cruel and unusual punishment for both the telescope and its operator. Thereafter, I piggybacked the TV 76 on my equatorially mounted 14-inch SCT as it tracked the westward motion of the sky above the high desert.

The TV 76 is compact. Its 21-inch (53-cm) long foam-lined soft carrying case, which has cutouts for six eyepieces or adapters, will fit easily in an airliner's overhead compartment. Overall, the telescope weighs in at less than seven pounds (≈3 kg). Its maximum length, with lens hood extended and 2-inch diagonal at extreme back focus, is only 22 inches (56 cm). This compresses to 17 inches (43 cm) for packing in the case. Traveling observers must remember to bring a mounting.

Rich-Field Optics: A Wide-Angle View

The TV 76, as its name implies, has an objective lens 76mm (≈3 inches) in diameter and a focal length of 480mm, yielding a focal ratio of 6.3. This relatively short focal ratio qualifies it as a "rich-field" telescope. A rich-field scope produces spectacular low-power views of wide areas of the Milky Way and of objects such as the Pleiades star cluster and the Andromeda Galaxy, all of which are too large in angular diameter to fit into the field of most larger telescopes. The TV 76's maximum theoretical field of view (with a long-focus eyepiece) is 5°. For comparison, Orion's belt is only 3° across and the "pointer" stars in the bowl of the Big Dipper are 5° apart.

By timing the transit of a star on the celestial equator across the field of view, I determined empirically the telescope's true field of view in two different eyepieces. The Nagler 31mm Type 5 (lovingly known to its users as "the pineapple," or sometimes "the hand grenade") yields a field of view of 5° and a magnification of 15x. The 20mm Tele Vue Plössl eyepiece — supplied with the TV 76 kit — provides a 2° field of view and a magnification of 24x. The four settings of the new 3mm–6mm Nagler Zoom eyepiece increased the view to the following magnifications: 6mm — 80x; 5mm — 96x; 4mm — 120x; 3mm — 160x.

Optical Test Grade: A

I tested the optical quality of the TV 76: Starting with inside-and-outside-of-focus star tests and split double stars, I then looked at bright stars and the moon for signs of internal glare and chromatic aberration. After that I performed a side-by-side comparison of the TV 76 against a friend's 76mm-aperture, 600mm-focal length Takahashi refractor.

The 3-inch objective lens of the TV 76 is a multicoated two-element design whose exotic glasses give the optical performance of an apochromatic objective lens. Traditional two-element achromatic designs leave an annoying color fringe around bright objects because achromats often have difficulty bringing the different colors of light fully to a common focus. The TV 76 passes the bright-object test with (pardon the expression) flying colors. A look at the bright stars Vega and Capella, with magnifications ranging from 24x to 160x, revealed only a faint violet haze around the star.

I found an almost imperceptible glitch in the TV 76's field of view when using a low-power eyepiece such as the Nagler 31mm: The field appeared somewhat curved, leaving stars at the edge at a slightly different focus than stars in the center of the field. Only those wishing to do astrophotography will even notice this and should use Tele Vue's field-flattening lens.

List prices for the TV 76 are $1,275 for the optical tube only, and $1,675 for the kit, which includes a Tele Vue 20mm Plössl eyepiece, a 2-inch diagonal, a 1.25-inch eyepiece adapter, and the soft carrying case.

Tele Vue Optics, Inc., 32 Elkay Dr., Chester, NY 10918; (845)-357-9522; website: www.televue.com.

The Moon

The moon seen through the TV 76 is tack-sharp at all magnifications, with no glare or false colors in the view. Stars near the bright limb of the moon are easily picked out because of the absence of glare in the telescope.

Double Stars and Planets

In-and-out-of-focus star tests, star diffraction patterns, and the ability to resolve various double stars reveal the TV 76's top-notch optical quality. If the atmospheric seeing permits, the TV 76 easily resolves doubles with a separation at the theoretical limit for a 76mm aperture scope of 1.6". Planetary views in the TV 76 are best seen through the higher magnifications offered by the 3mm–6mm Nagler Zoom eyepiece. Jupiter and Saturn reveal subtle color variations and both planets' retinues of moons are visible. When the seeing conditions are good, the TV 76 reveals atmospheric belts on Jupiter beyond the two prominent equatorial belts, as well as Cassini's division in the rings of Saturn.

In Its Element: The Deep-Sky

When used as a rich-field scope for deep-sky viewing, the TV 76 excels. With a long focus eyepiece in the 2-inch diagonal, the scope offers impressive views of "showpiece" objects that are too large in angular diameter to fit into the smaller fields of view of larger telescopes. Under a dark Arizona sky, the Andromeda Galaxy (M31) shows its full 3° extent, including its central dust lanes and two companion galaxies — M32 and NGC 205. Dozens of stars in the Pleiades cluster look like sparkling diamonds scattered on black velvet.

The TV 76 "light cup" provides surprisingly good views of large nebular objects. I threaded Lumicon's UHC (Ultra High Contrast) filter into the "pineapple" eyepiece (i.e. the Nagler 31mm Type 5) and it yielded clear views of the full extents of the North America Nebula and of the Cygnus Loop, a supernova remnant in the summer Milky Way.

Evaluating Your Choices

The Tele Vue 76 is a fine choice for observers who require both high quality and extreme portability. It's easy to lug around without taking over your luggage. Drawbacks for some may include its fairly expensive price and the limited light-gathering ability inherent in any 3-inch objective lens. But the high-quality telescope will deepen your appreciation of the wonders found in the night sky. ◼

David Healy is a frequent contributor specializing in equipment reviews. John Cassella helped out with some optical performance tests.

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Offer Good Through: October 5, 2002

Horologium, Reticulum, and Caelum

Within the Clock you'll go back in time to find some of the Southern Hemisphere's most distant galactic gems.

by Tom Polakis

As summer arrives in the Southern Hemisphere, Canopus and the Large Magellanic Cloud ride at their highest. Just west of this neighborhood you can find three small, formless constellations tucked away that offer a window on some of the most distant galaxies. Observers in the southern United States can capture these galactic gems just before dawn when they scrape the southern horizon.

Horologium the Clock links a chain of a half dozen 5th-magnitude stars punctuated by 3rd-magnitude Alpha (α) Horologii at the north end. This yellow-white star — 160 light-years away — lies more than a half-degree west of Delta (δ) Horologii, a similarly distant star but nearly two magnitudes fainter.

The smaller, more recognizable constellation Reticulum the Net lies adjacent to the southern half of Horologium. Its brightest stars form a diamond shape 7° long and 2° wide. The constellation's brightest star, Alpha Reticuli, shines at 3rd magnitude at a distance of 160 light-years. Zeta (ζ) Reticuli — a close naked-eye pair of 5th magnitude suns separated by 5' — lies on the western edge of the constellation. Our proximity to the pair (only 40 light-years), along with the fact that their spectral types are identical to the sun, has elevated Zeta Reticuli to special status in UFO lore.

Caelum the Graving Tool is detached to the north of Reticulum. It holds only several naked-eye stars in its small boundaries. Both Alpha and Beta (β) Caeli shine six times as bright as the sun in absolute magnitude.

A line extended from Beta through Mu (μ) Horologii nearly lands telescopes on the stray globular cluster **NGC 1261**. The cluster holds stars as bright as magnitude 13.5, which resolve well in a 10-inch scope from a dark rural site. In this aperture NGC 1261 appears 4' across, and highly concentrated to a stellar center. A small clump of five stars sparkles on the northern edge. NGC 1261 lies 50,000 light-years away.

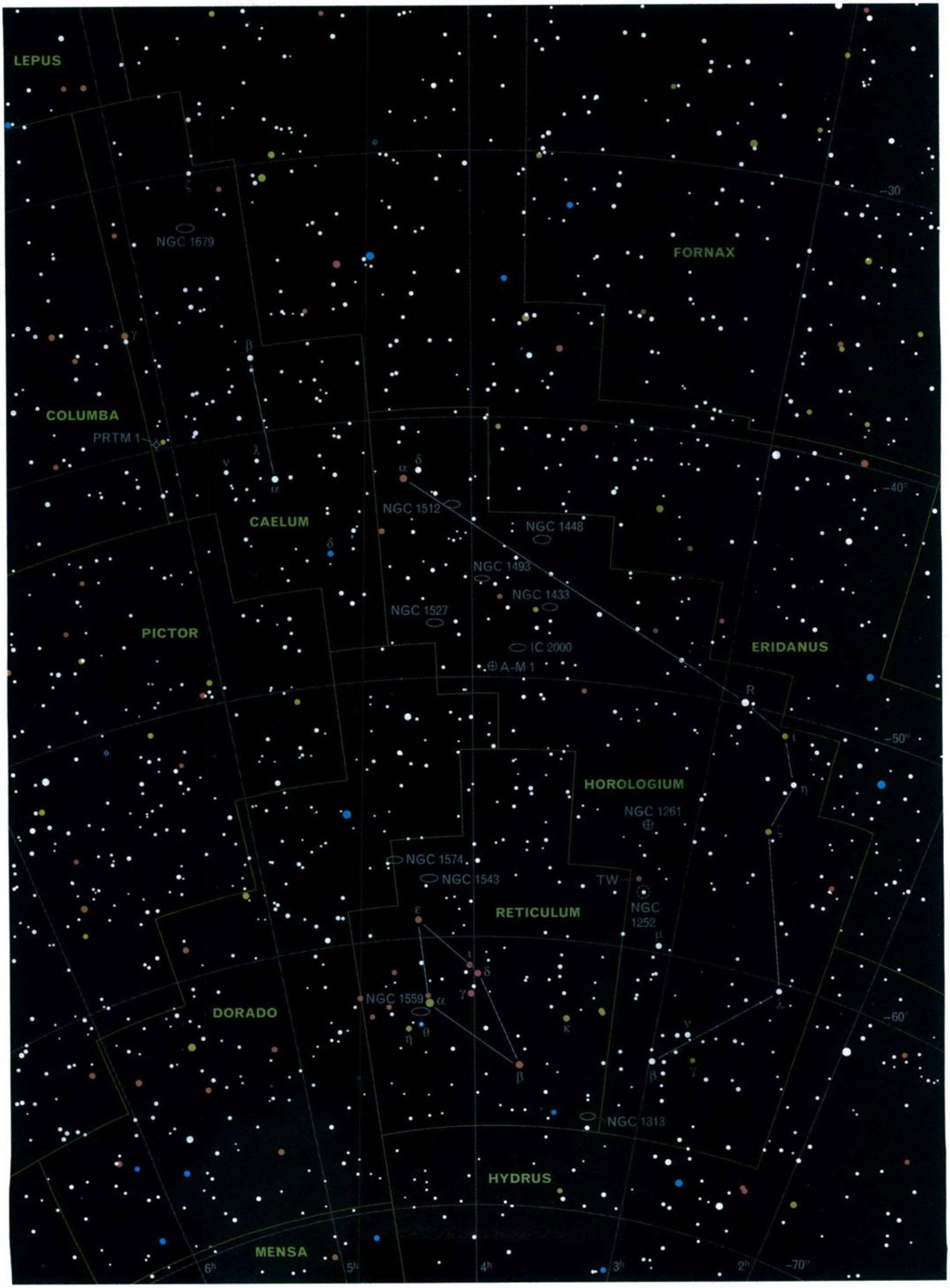
Just 3° south of NGC 1261 lies **NGC 1252**, which some argue is a true open cluster with a concentration of 20 stars. A recently acquired color-magnitude diagram shows a dozen of its probable members at a distance of 2,000 light-years. NGC 1252 may be a remnant of an open cluster, similar in nature to M73. However, proper motion data collected by the Hipparcos satellite indicate that the stars are unassociated. A small telescope reveals a group of 11th- to 14th-magnitude sunlike stars in an area 6' across. On NGC 1252's southern edge lies a yellowish 6th-magnitude star.

Pan only a half-degree north-northeast and you'll spot the bright carbon star **TW Horologii**. Astronomers have recently ruled it out as a member of NGC 1252. As one of the sky's brighter carbon stars TW Hor can be seen in binoculars. TW Hor is listed in catalogs as a variable star, but its amplitude of variation is only 0.2 magnitude around its nominal magnitude of 5.8.

Located in the southwest corner of Reticulum, **NGC 1313** sits 15 million light-years away as an isolated galaxy, between the Large Magellanic Cloud and a late-type spiral galaxy. Because of its relative proximity it appears plenty bright with significant detail. NCG 1313 holds an active bar and spiral arms, as well as star-producing regions — all of which telescopes with even modest apertures reveal. From a quality observing site my 13-inch showed a bright bar 5' long with a central bulge. Moreover, a

Left: *Astronomy*: Elisabeth Rowan; Right: Anglo-Australian Telescope Board

NGC 1313


LEPUS
COLUMBA
PRTM 1
CAELUM
PICTOR
DORADO
MENSA
FORNAX
ERIDANUS
HOROLOGIUM
RETICULUM
HYDRUS
NGC 1679
NGC 1512
NGC 1448
NGC 1493
NGC 1433
NGC 1527
IC 2000
A-M 1
NGC 1261
NGC 1574
NGC 1543
TW
NGC 1252
NGC 1559
NGC 1313
R
-30°
-40°
-50°
-60°
-70°
6h
5h
4h
3h
2h

spiral arm divided into two elongated sections extends at a right angle to the east from the north end of the bar. A fainter arm juts out rather inconspicuously from the south end of the bar.

A formidable double star lies less than 1° south-southeast of the brightest star in Reticulum. You can easily spot the 6th-magnitude primary star Theta (θ) Reticuli, but the challenging secondary is two magnitudes fainter and separated to the north by only 3". Magnification in excess of 150x on a night of good seeing should help resolve the duo.

Move the telescope one-half degree north of Theta Reticuli and you'll find the bright barred spiral galaxy **NGC 1559**. An 8-inch scope at a dark site shows only a bright haze 3' long and half as wide. The galaxy is nearly uniform, but larger aperture picks up some mottling, which alludes to a barred spiral nature. The prolific supernova hunter Robert Evans discovered a "new star" in NGC 1559 in 1986. The star's brightness helped a team of astronomers gauge the distance to this curious galaxy, which turned out to be roughly 50 million light-years.

NGC 1543 is a fine example of a ringed galaxy. Long-exposure images reveal a faint circular ring beyond the extent of the spiral galaxy's bar. Backyard telescopes will not show this feature, but will easily reveal a strongly concentrated bar 3' long. A 9th-magnitude star 5' to the south illuminates the field.

NGC 1559

P. E. Andersen

Only 1.5° northeast lies the disk galaxy **NGC 1574** in the well-populated and relatively nearby Dorado Group. Located just over 30 million light-years away, NGC 1574 appears as a moderately bright, circular smudge 2' in diameter.

Try to hunt down **NGC 1448** — a spiral galaxy seen nearly edge-on. A 13-inch telescope shows a bright spindle 5' by 1' oriented at a 45° angle. The galaxy brightens gradually from the ends to its broad core. A 13th-magnitude star shines just southeast of center.

Scan 2.5° south of NGC 1448 and spot the bright galaxy **NGC 1433**, a prototypical ringed, barred spiral. Observe how gas has accumulated at positions that orbit resonantly with the bar, forming the characteristic shape of the Greek letter θ. At 40 million light-years, NGC 1443 displays excellent detail. Check out the core and nucleus, which appear 2' wide and twice as long. And look for a larger outer halo that begins to show hints of spiral arms.

Residing 2° to the southeast of NGC 1443, the galaxy **IC 2000** appears as a barred spiral viewed edge-on. In a 10-inch telescope it's a spindle 3' by 1', and oriented east-west.

We now depart from galaxies and arrive at another globular cluster far, far away from our galaxy's center. At a distance of nearly 400,000 light-years, **Arp-Madore 1** is the most distant known globular cluster in the Milky Way. Astronomers discovered it on plates taken by the UK Schmidt telescope in 1979. AM-1's relatively low luminosity makes it

Deep-Sky Objects in Horologium, Reticulum, and Caelum

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep.	Type	Notes
NGC 1252	3h10.8m	–57°46'	—	9'	OC	Asterism
NGC 1261	3h12.3m	–55°13'	8.3	6.9'	GC	
TW Horologii	3h12.6m	–57°19'	5.7	—	Star	Carbon star
NGC 1313	3h18.3m	–66°30'	8.9	11.0' by 7.6'	Gal	SB(s)d
NGC 1433	3h42.0m	–47°13'	10.0	5.5' by 3.2'	Gal	SB(r)ab
NGC 1448	3h44.5m	–44°39'	10.8	6.5' by 1.4'	Gal	SAcd
IC 2000	3h49.1m	–48°52'	11.0	4.1' by 0.8'	Gal	SB(s)cd
Arp-Madore 1	3h55.0m	–49°36'	15.0	1.7'	GC	
NGC 1493	3h57.5m	–46°12'	11.2	3.5' by 3.2'	Gal	SB(r)cd
NGC 1512	4h03.9m	–43°21'	10.2	8.3' by 3.6'	Gal	SB(r)a
NGC 1527	4h08.4m	–47°53'	10.7	4.2' by 1.8'	Gal	SAB(r)0
NGC 1543	4h12.8m	–57°44'	9.7	7.2' by 4.9'	Gal	SB(s)0
NGC 1559	4h17.6m	–62°47'	10.4	4.3' by 2.2'	Gal	SB(s)cd
Theta Reticuli	4h17.7m	–63°15'	6.2/8.2	2.9"	Dbl	
NGC 1574	4h22.0m	–56°58'	10.2	4.0' by 3.6'	Gal	SA(s)0
NGC 1679	4h50.0m	–31°59'	11.5	3.0' by 1.5'	Gal	SB(s)m
PRTM 1	5h03.0m	–39°46'	—	23"	PN	

Object: Designation in NGC or other catalog. **R. A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds. **Notes:** Hubble type for galaxies.

The Clock

One luminary clock against the sky
Proclaimed the time was neither wrong nor right.
I have been one acquainted with the night.
Acquainted with the Night, *Robert Frost* (1874–1963)

Once European explorers had named and mapped the Southern Hemisphere's landmasses and water bodies, their focus only had one place to turn — the southern sky and its store of celestial novelties.

In the middle 18th century, the Frenchman Nicolas Louis de Lacaille built an observatory on the Cape of Good Hope, from where he would chart much of the southern sky. He created numerous constellations, which he thought represented the tools used in the arts and sciences of his day.

The constellation Horologuim was originally named Horologium Oscillitorium to honor Christian Huygens, the famous Dutch scientist who many might know as the discoverer of Saturn's rings. But Huygens also gained fame as inventor of the pendulum clock in 1656. Later generations of skygazers shortened this tongue-challenging designation to just Horologium.

The constellation Reticulum was originally named Rhombus by Swiss inventor and celestial frontiersman Isaak Habrecht. However, de Lacaille re-christened it the Reticle, which was the name for the crosshairs in a telescope's eyepiece. This constellation is also referred to as the Net.

The rather sparse and non-descript region of sky between Columba and Eridanus was named Caelum by Lacaille. The Latin word caelum means "graving tool." — *Paul Morledge*

an extremely challenging object to observe. From a good site, a medium-sized Newtonian picks up the cluster as an extremely faint, circular haze less than 1' across with no sign of stars.

Returning to galaxies we find the S0 disk galaxy **NGC 1527**. In an 8-inch scope, it appears as a moderately bright haze 3' by 1.5' with a bright core region. A 13th-magnitude star is superposed on the west end and a 12th-magnitude star appears to the north of the galaxy's halo. NGC 1527 is 50 million light-years away.

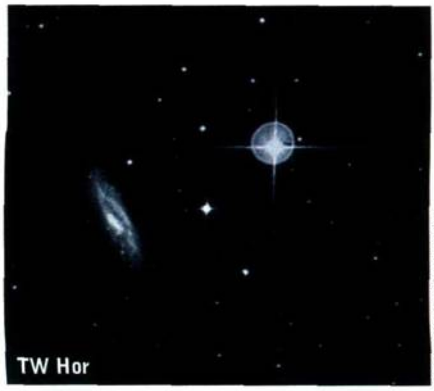
NGC 1493 is a face-on barred spiral galaxy that exhibits an unusually luminous center. Some observers think this may represent a young supercluster, though no hydrogen-α emission has yet been detected. Seen at a distance of 40 million light-years, NGC 1493 appears as a faint, circular smudge that gradually brightens to a central core. Only large telescopes pick up the central bar.

At the apex of a long triangle with Alpha and Delta Horologii lies **NGC 1512**, another barred spiral galaxy featuring a surrounding ring. In a 13-inch telescope you might capture its spiral structure as brighter areas at both ends of the 4' bar. The structure is more prominent at the northeast end, where a faint arm wraps tightly around to the south. The core area is very bright, and concentrates to a nearly stellar nucleus. Masquerading as a supernova is a 14th-magnitude star in the northern spiral arm. Images taken with the Hubble Space Telescope showed a ring 150,000 light-years in diameter dotted with small, young open clusters.

Optical observations of **PRTM 1** will be among some of the first on the planet, since this lonely planetary nebula was discovered only in 1990. Astronomers found it as part of a survey for emission-line objects that employed a 24-inch Schmidt camera and a full-aperture prism. Viewing from California, Kent Wallace made what is likely the first visual observation of PRTM 1 with his 20-inch telescope. He saw it as a small disk that responds well to a nebula filter. At 250x he spotted its magnitude 15.6 central star.

NGC 1679 is our most northerly object. This barred spiral galaxy presents a strange face due to the presence of several superposed stars. It appears as a 2' by 1' oval haze that brightens slightly at the center. An 11th-magnitude star lies just beyond the northwest end, and a 13th-magnitude star glimmers in the outer halo to the east.

Tom Polakis is a man of the sky whose favorite pursuits are observing and astrophotography.



TW Hor

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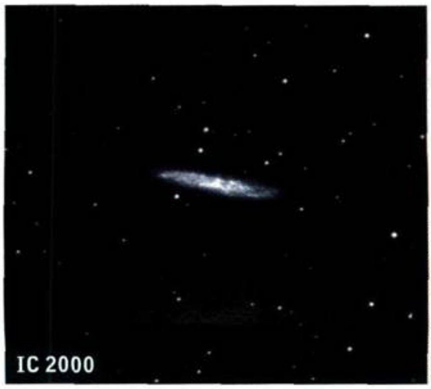
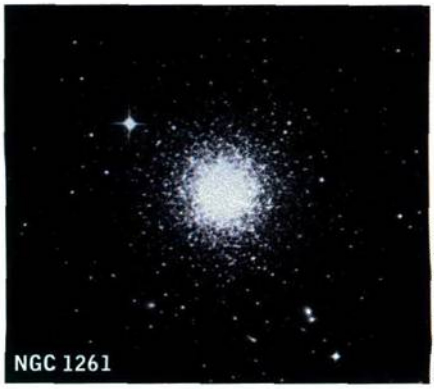


IC 2000

STScI Digitized Sky Survey



NGC 1261

STScI Digitized Sky Survey

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Beginner's sky

Diary of a neophyte astronomer. by Jerry Burstein

"For we live on this Earth and always shall. After the day is gone we shall go out, breath deeply, and look up — and there the stars will be, unchanged, unchangeable. Even from the moon, Mars, or from Pluto, the outermost planet, the stars look the same as they do from Earth. Night after night they are there. And night after night they arouse our curiosity, our urge for knowledge. Man will be asking the question his grandparents had asked before him and his grandchildren will ask after him: "What star is that?"

One of the best investments I've made since being introduced to the hobby of astronomy these last several months has been to purchase the book that this excerpt came from, *The Stars: A New Way To See Them* by H. A. Rey. I'm not talking about just the financial investment made but the wonderful payback I'm receiving from the investment in time spent reading and sharing this great book with my daughter. I urge you to pick up a copy and have as much fun as we have had exploring its pages.

Amanda and I have met frustration in trying to focus in on one particular celestial object lately (with the exception of the blazing planet Venus, which we enjoyed watching close in on Jupiter in June. We even managed to catch binocular views of some of Venus's phases). Our astronomical activities this past month have mostly included reading Rey's book and going outside to observe some constellations with the naked eye. On a couple of clear, moonless nights we managed to glimpse the Milky Way (remember, we live way out in the boonies).

Rey described how the sky appears to rotate (as we all know the sky doesn't rotate but Earth does) in terms of visualizing a giant, spinning umbrella — an analogy that really made the concept of the celestial sphere clear for both my daughter and me. Cassiopeia (the big W or M) and the Big Dipper are always visible in the night sky as they go around the North (Pole) Star (center of the umbrella) with Cassiopeia always opposite the Dipper. Four other constellations including the Little Dipper, Cepheus, Draco (the Dragon), and Camelopardalis (the Giraffe), are termed circumpolar as they travel around the North Star and can pretty much be seen any time of the year.

From there we took Rey's suggestion to remember constellations in groups: For example, we started trying to identify the "Carnivore's Corner," which includes the Great Bear, Big and Little Lion, the Hunting Dogs, Lynx, Dragon and Little Bear.

After reading that both Cepheus and Cassiopeia lie in the Milky Way (Cepheus only partly sometimes), Amanda wanted to know more about our galaxy as we attempted to spot it in the southern sky. I was surprised to learn that gala is a Greek word meaning milk. We also learned that more than one hundred billion stars inhabit our galaxy alone. And that the Milky Way appears brighter in the summer than in the winter because we're actually looking into a greater number of stars (toward the center of the galaxy). The big strip we see is a result of our galaxy's disk-like shape (Rey aptly describes it as an immense lentil, or a flat round loaf with a frayed edge, roughly 100,000 light-years across and 10,000 light-years thick at the center). The solar system is situated about halfway from the middle to the edge on one side of this disk.

The Milky Way is inclined about 63° to the celestial equator. Most of its stars are too faint to be seen individually, but on a rather clear moonless night some of my observing friends down the street have reported seeing a dense collection of rather bright stars that collectively compose what is referred to as the galaxy's band. The Milky Way's stars are often more observable because the sun lies so close to the central plane of the galactic disk, which is quite flat and rather translucent. And because this disk is relatively thin compared to the galaxy's other components (bulge, thick disk, etc.) a much greater concentration of stars are visible within this rather wide-open plane.

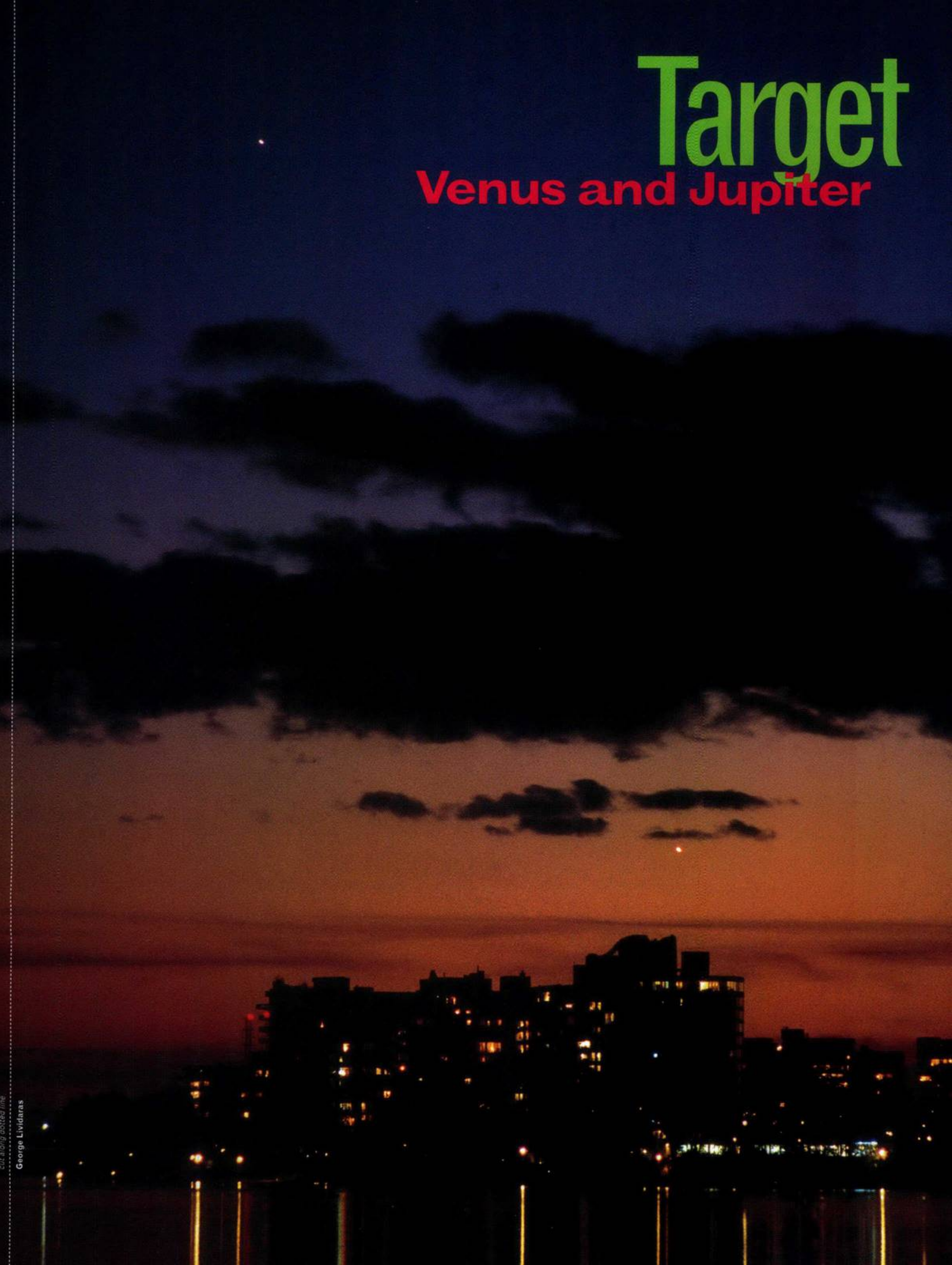
Have we seen a good view of the Milky Way yet? No, not really. But we're not giving up. We have met a lot of wonderful people who have volunteered their help, and I've heard from many of you *Astronomy* readers who have eloquently detailed your observing experiences. I would love to hear more about your tips for beginners and suggestions on how to keep from getting discouraged. So email me at jerry@astronomy.com with your thoughts.

Again, as H. A. Rey says, "Of course one can enjoy the stars without knowing them. But if you know them at least a little the pleasure is infinitely greater. Besides, if you know the stars you are not easily lost."

Have fun!

Target

Venus and Jupiter



George Lividaras

cut along dotted line

Capturing Naked-Eye Variables

by Philip Pugh

Many astronomical adventures involve expensive equipment, dark skies, and the ability to stay awake into the wee hours. Fortunately, there are some observing challenges requiring none of these.

In fact, all you need to observe and estimate bright variable stars is a basic knowledge of the night sky, a sheet of paper, and a pencil.

However, before you head out into the night and fix your gaze skyward, it's imortant to get acquainted with the different types of variable stars.

The Many Variables

Aside from the sun, Aldebaran and Betelguese are the two brightest variable stars we can see with the naked eye. Their variation is caused by irregular fluctuations in the emission of photons from the expansion and contraction of the stars's outer layers. One of the next brightest stars is Algol [Beta (β) Persei], which is an eclipsing variable. It consists of a close binary system where in one star passes in front of another and reduces the visual brightness of the pair. Algol varies from magnitude 2.1 to 3.4 over just 10 hours, with the most marked change taking place over just 5 hours. Eclipses take place about every 34 hours. Beta Lyrae is also known as an eclipsing variable visible to the naked eye.

Cepheid variables constitute another class of naked-eye variables. The brightest member of this class is Polaris, but its variations are so small that they're difficult to detect without a photometer. As far as Cepheids go, the naked eye can only detect varying brightness in Delta (δ) Cephei (after which the class is named) and Eta (η) Aquliae.

To find all the naked-eye variables, you really need a good star atlas or "planetarium" program on a PC. Mira (Omicron [o] Ceti)-type variables are semi-regular but their maxima can be difficult to predict. In the case of Mira itself, its maximum can reach magnitude 2.0 but can be as low as magnitude 4. There are also stars that are usually well behaved but will occasionally brighten or fade. These are always worth the odd glance and include Dubhe (Alpha Ursae Majoris) and Gamma (γ) Cassiopeia.

Irregular variables usually have a range but their brightness changes follow no known pattern.

Getting Started

The brightest variable star of all, Betelgeuse (α Orionis), is a snap to find: It lies at Orion's right shoulder and is usually the second brightest star in that constellation. Catalogs list Betelgeuse as a semi-regular variable with a magnitude range of 0.0 to 1.3. However, the star's more normal range is 0.3 to 0.7. When at its brightest, it appears as bright or even brighter than Rigel (the bright star at Orion's bottom right), which shines at magnitude 0.12. However, because Betelguese's ruddy color appears different than Rigel's blue-white hue, comparisons in brightness here are a bit tricky.

The red supergiant Betelgeuse varies from about magnitude 0.0 and 1.3 over a period of some 5.9 years. John Chumack

But don't fret — help is at hand. And strangely enough, it comes in the form of another variable star — Aldebaran. You can spot this slow irregular variable star by following a line from Orion's belt upward and to the right into the constellation Taurus. For much of this past winter, Saturn hovered near the reddish Aldebaran, which catalogs list as having an average magnitude of 0.85 — not as variable as Betelguese.

Pollux in Gemini glows slightly fainter than Aldebaran (at least most of the time) and serves as a good comparison star. To find Gemini, just follow an imaginary line from Rigel through Betelguese. The more easterly of the two bright stars in Gemini, Pollux appears more orange than either Betelgeuse or Aldebaran, but is a better color match than most other nearby stars. Pollux is magnitude 1.12.

Estimating Betelgeuse and Aldebaran

Estimating the average luminosity of a variable star may seem simple enough, but it actually requires a lot of practice. Ideal comparison stars should be similar in color and elevation from the horizon. If you're observing from urban sites, you should always consider the relative elevation of the two stars you're comparing. Otherwise inaccuracies in your luminosity estimates will occur. For example, due to light pollution, Procyon (magnitude 0.38) might appear as bright as (or brighter than) Rigel when it's higher in the sky. If so, treat any of your eventual comparisons with suspicion.

The first stage is to check the brightness of Betelgeuse against Rigel and Procyon. If it's somewhat between the two, then it must be somewhere in the range of magnitude 0.12 to 0.38. If it is noticeably fainter than Procyon, then take a stab at somewhere from magnitude 0.5 to 0.9.

Next, compare Aldebaran to nearby Pollux. I have seen it slightly fainter than Pollux (1.12) but it's usually a bit brighter. Aldebaran is somewhere between 0.5 and 1.0 magnitudes brighter.

The final stage is to check your estimate of Betelgeuse against Aldebaran. I've never yet seen Aldebaran outshine Betelgeuse but I've seen them glow similarly in brightness. Since they are similar in color, it is easier to detect genuine differences in brightness.

Sometimes I find my first guess at a star's magnitude is wrong, so I re-check it until I feel more confident about my estimate. With practice, I'm getting good at estimating to the nearest 0.1 in magnitude. Sometimes I'll record a magnitude at something like 0.65, but only because I couldn't decide between 0.6 and 0.7.

Recording Your Results

According to most references, both Betelgeuse and Aldebaran list as irregular, long-period variables. As such, these stars are not supposed to change in brightness over just a period of days. But my observations don't agree, which may well be due to atmospheric conditions, elevation, or some other factors I'm unaware of. I record the magnitude estimate and the date/time to the nearest half-hour. If you wish, you can start plotting a graph of magnitude versus time for a particular variable star over a few months.

If you have access to a personal computer you can record the magnitude against time for both stars using a spreadsheet package, such as EXCEL. However, to get a feeling for brightness you negate the magnitude and obtain the exponential (use the EXP) function. This will give you a positive measure of brightness, so the graph will go up as the star brightens (as the magnitude decreases). You need the EXP function, as magnitudes are measured on a logarithmic scale.

Philip Pugh is an active observer who observes from the famously clear skies of England.

Other Naked-Eye Variables

This list contains most known and suspected naked-eye variables visible from the Northern Hemisphere. This means a limiting magnitude of about 4.5 and about 3.5 for stars below –20° declination. For the fainter stars in the range, it's best to use a planetarium-type computer program to find suitable comparison stars.

Name	Range	Comments
Alpha (α) Cassiopeia	2.2–2.5	Suspected
Rho (ρ) Persei	3.0–4.0	Just below Algol
Beta (β) Pegasi	2.3–2.7	Semi Regular, period about 38 days
Epsilon (ε) Aurigae	2.9–3.8	Eclipsing binary, period about 30 years
Zeta (ζ) Aurigae	3.7–4.0	Eclipsing binary, period about 3 years
Zeta (ζ) Geminorum	3.7–4.1	Cepheid, period just over 10 days
Eta (η) Geminorum	3.2–3.9	Semiregular
Chi (ξ) Cygni	3.3–14.2	Mira type, maximum is usually fainter than 3.3
Beta (β) Lyrae	3.3–4.3	Eclipsing binary, period just under 13 days
Mu (μ) Cephei	3.4–5.1	Irregular
P Cygni	3.0–6.0	Irregular
Lambda (λ) Tauri	3.3–3.8	Eclipsing binary, period just under 4 days
R Leonis	4.4–11.3	Mira type. Only visible to the naked eye near maximum
Eta (η) Aquilae	3.5–4.4	Cepheid, period just over 7 days
Alpha (α) Herculis	3.0–4.0	Semiregular
Antares	0.8–1.3	Very low at northern latitudes, difficult
Delta (δ) Scorpii	1.8–2.3	Recently discovered

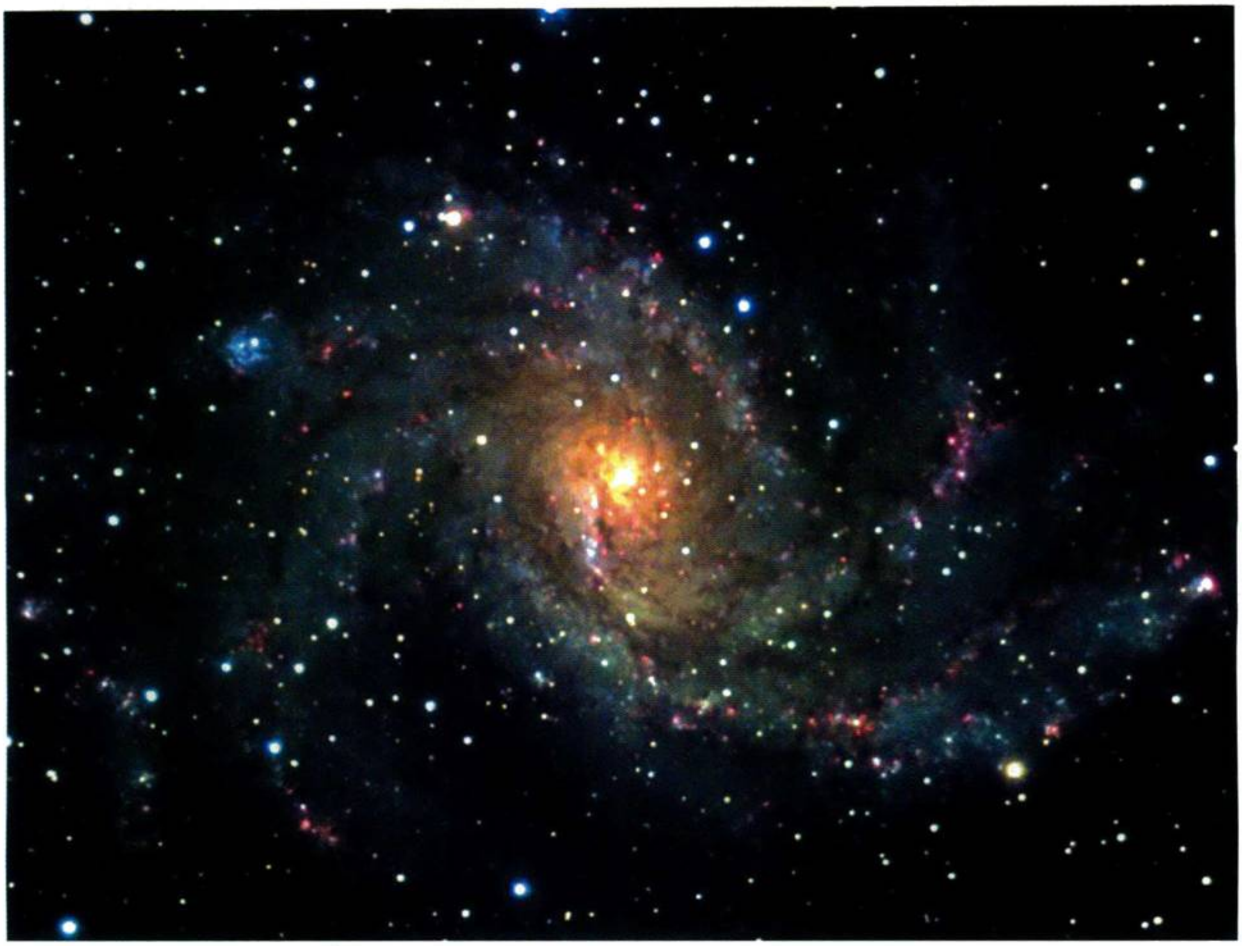
Capture the Sky from Kitt Peak

At some point, every amateur astronomer has a certain kind of dream. For some, it's owning a large Dobsonian and using it from a dark sky site. For others, it's spending a night at one of the world's great observatories, capturing the sky on film. The second dream has been a potential reality for some time now thanks to Kitt Peak National Observatory's Advanced Observing Program. For a price, visitors to the peak, which stands 56 miles southwest of Tucson, Arizona, can pony up to a 16-inch SCT and SBIG ST8E CCD camera and use the equipment to make spectacular color composite images of favorite deep-sky objects, or to record video footage of the moon and planets. Or one can simply gawk through hefty telescopes under some of the best skies in the southwest.

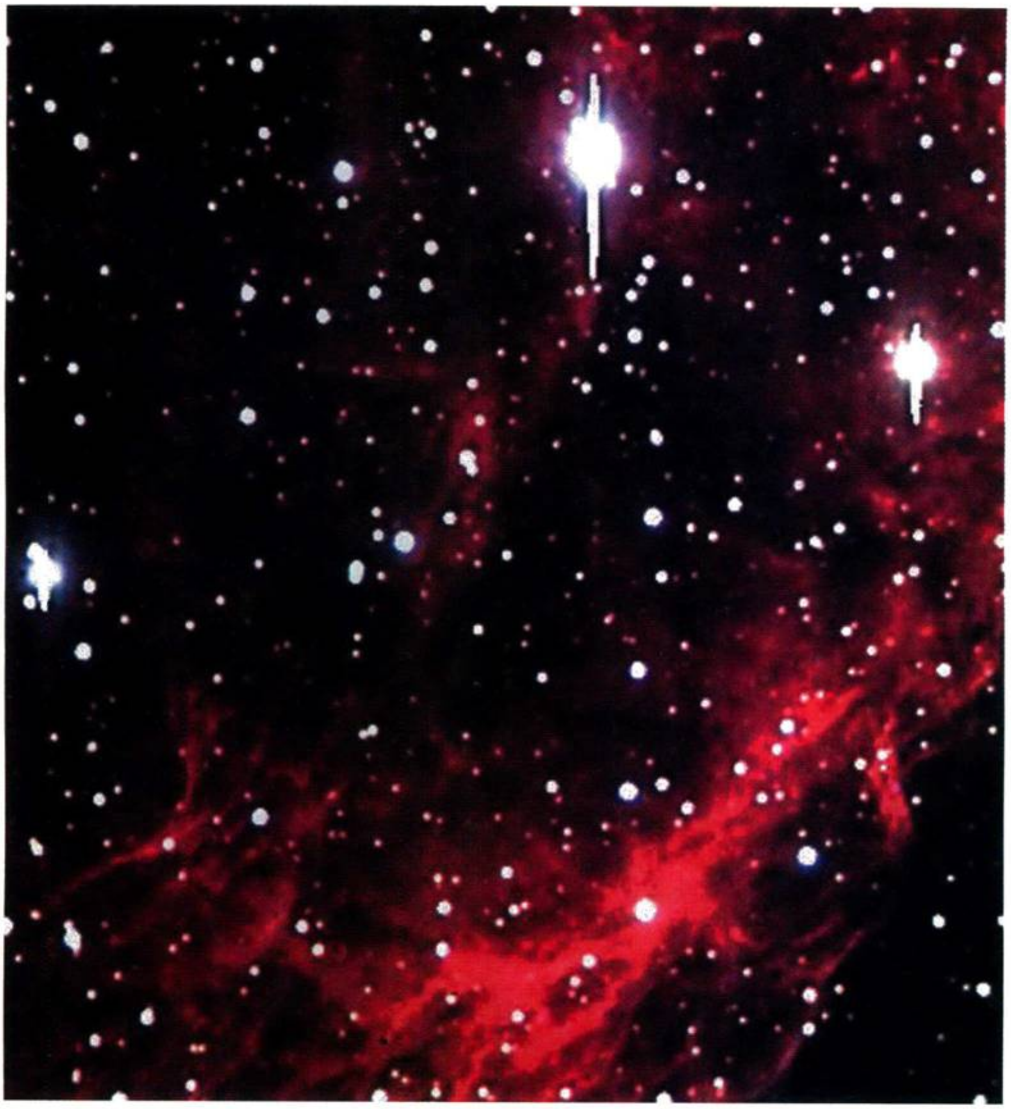
The program, run by the National Optical Astronomy Observatories, unfolds under the guidance of professional astronomer Adam Block. Cost is $350 per night for the 16-inch dome (maximum of two people per session), and $55 per night per person for room and board. For astronomy-minded tourists, it is an opportunity that would be hard to top. For more information, contact Block at ablock@noao.edu, or call (520) 318–8728.

The most beautiful product of the Advanced Observing Program is the collection of stunning color imagery that grows each month. The editors of *Astronomy* delight in sharing a small selection of the most spectacular images from the series on these pages. Each is an LRGB color composite CCD image, produced by a special technique that is more complex than the standard tricolor CCD process. Block and his associates composite a red, green, and blue frame that can be registered digitally into the final color image for each object, but also add a luminance layer that lets all the colors of light pass through.

Making a luminance exposure saves time by reducing the total exposure needed and provides in effect a high-resolution monochrome image that can then be added into the lower-resolution color images. The final result is an image with apparent sharp, vivid detail in addition to the beautiful colors of galaxies and nebulae.

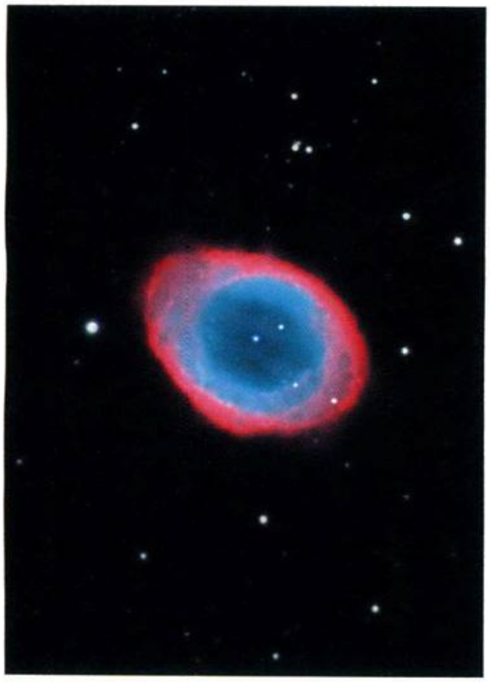


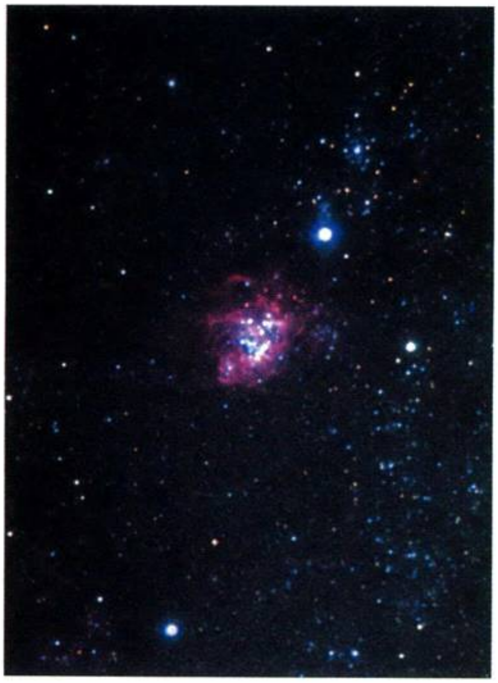
The spiral galaxy NGC 6946 in Cepheus, imaged with a 16-inch SCT at f/6.3 and f/10 and LRGB exposures of 125, 20, 20, and 30 minutes. Adam Block, NOAO/AURA/NSF



Supernova remnant IC 443 in Gemini offers a ghostly trace visible in telescopes. This portrait was made with a 16-inch SCT at f/6.3 and LRGB exposures of 40, 10, 10, and 20 minutes.

Chip Levinson and Adam Block, NOAO/AURA/NSF



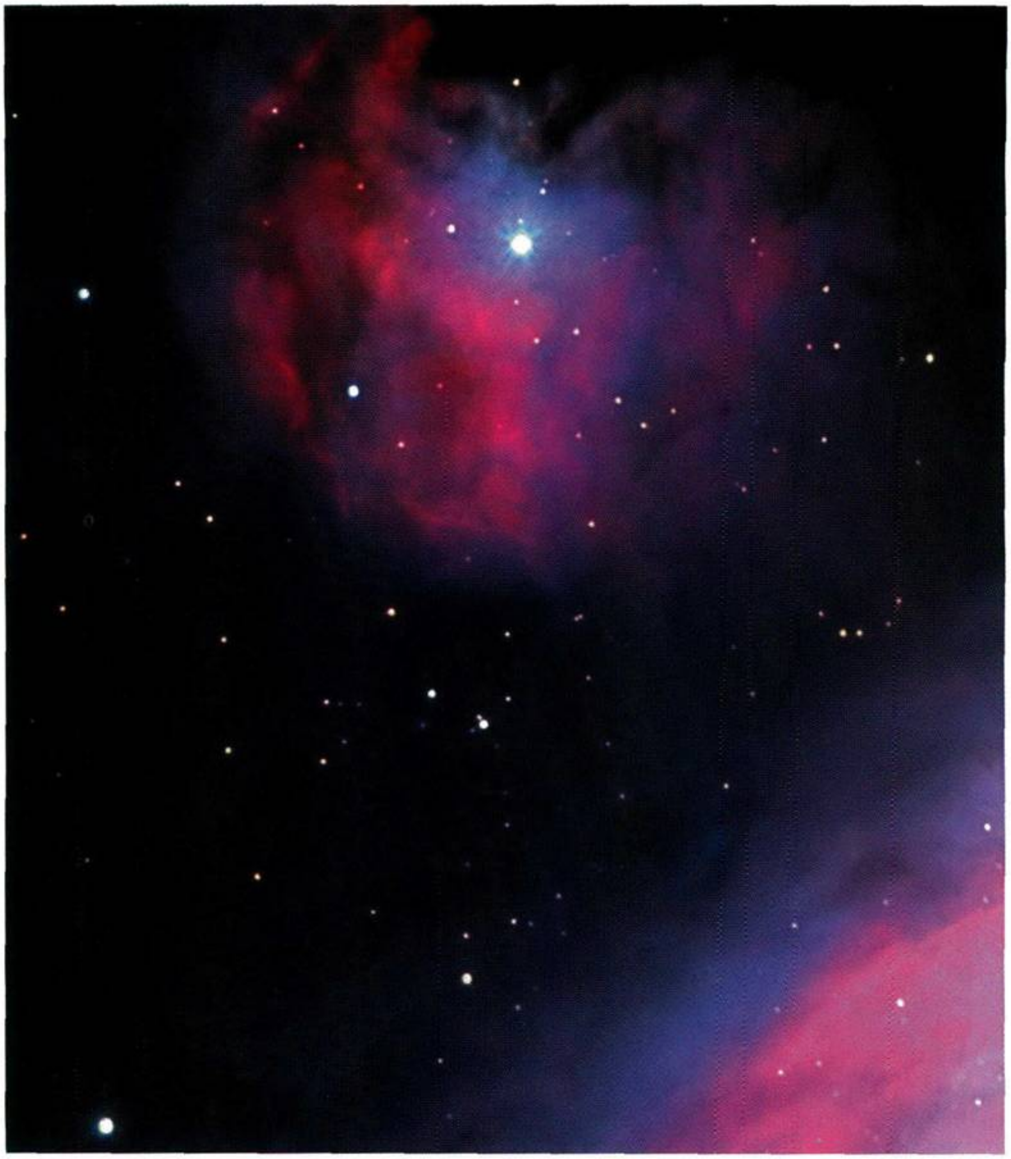


Far left: The Ring Nebula in Lyra, shot with the 16-inch SCT at f/10 and LRGB exposures of 40, 6, 6, and 12 minutes.

Anne, Karen, and David Rajala and Adam Block, NOAO/AURA/NSF

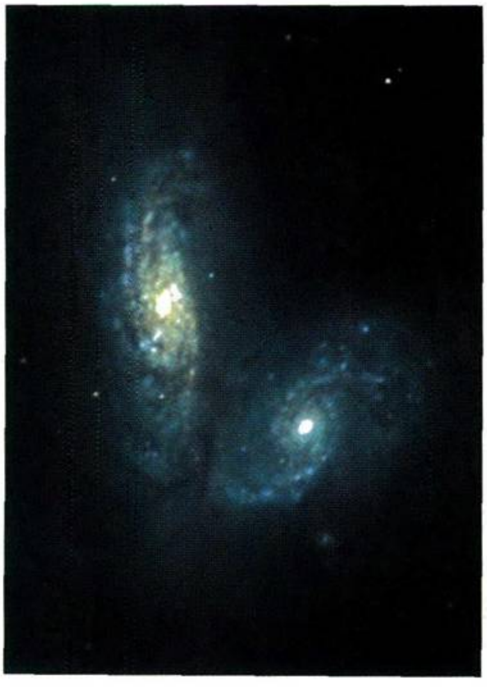
Left: NGC 604, the giant nebula in M33, imaged with the 16-inch SCT at f/10 and LRGB exposures of 100, 24, 24, and 48 minutes.

Adam Block, NOAO/AURA/NSF



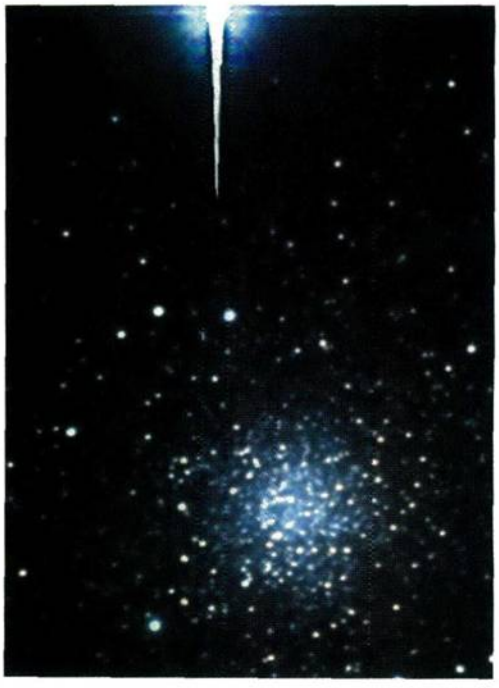
The emission region M43, a portion of the *Orion* Nebula, imaged with the 16-inch SCT at f/10 and LRGB exposures of 33, 6, 6, and 12 minutes.

Darlene Stapleton and Adam Block, NOAO/AURA/NSF



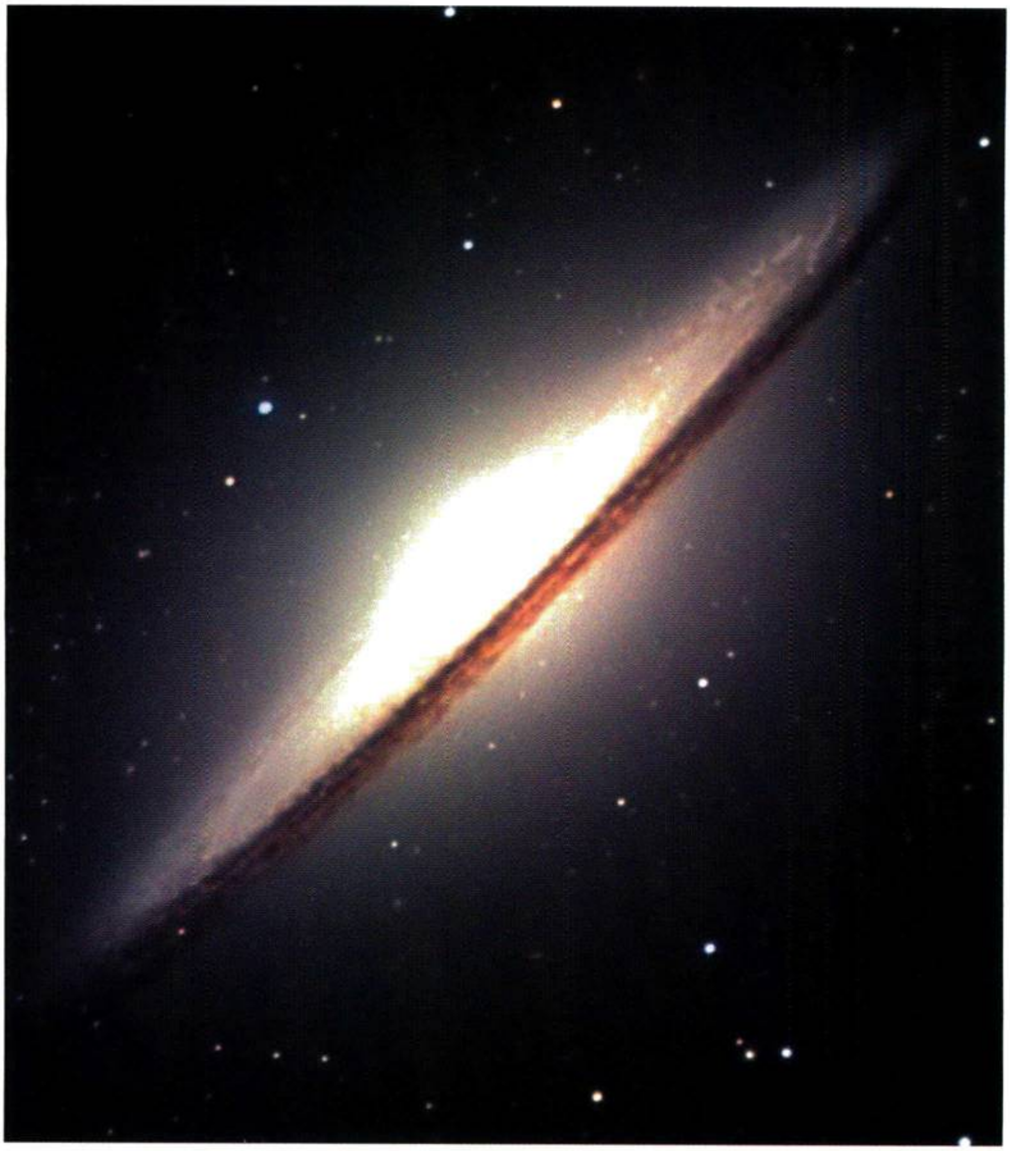
Right: Interacting galaxies NGC 4567 and NGC 4568 shot with the 16-inch SCT at f/10 and LRGB exposures of 70, 20, 20, and 30 minutes.

Don Wagner and Adam Block, NOAO/AURA/NSF



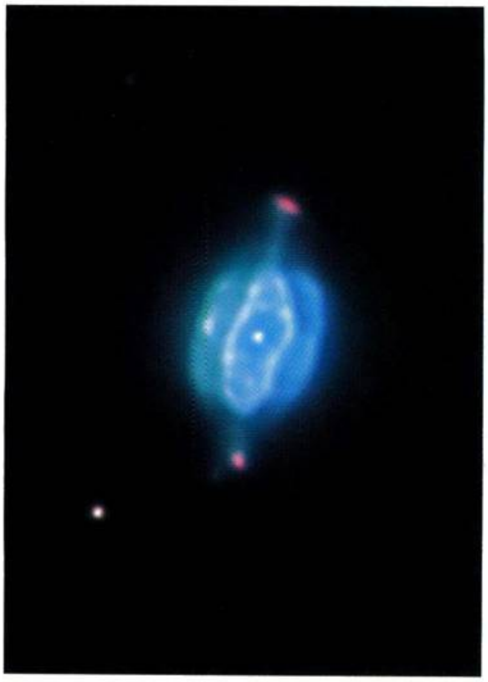
Far right: Distant globular cluster NGC 2419 in Lynx imaged with the 16-inch SCT at f/10 and LRGB exposures of 30, 10, 10, and 20 minutes.

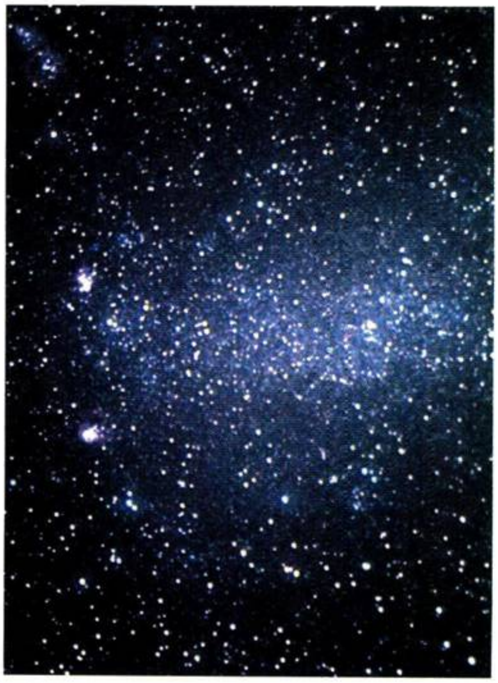
Jim Rada, Karen Jensen, and Adam Block, NOAO/AURA/NSF



The Sombrero Galaxy (M104) in Virgo shot with the 16-inch SCT at f/10 and LRGB exposures of 70, 20, 20, and 30 minutes.

Don Stotz, Mike Ford, and Adam Block, NOAO/AURA/NSF





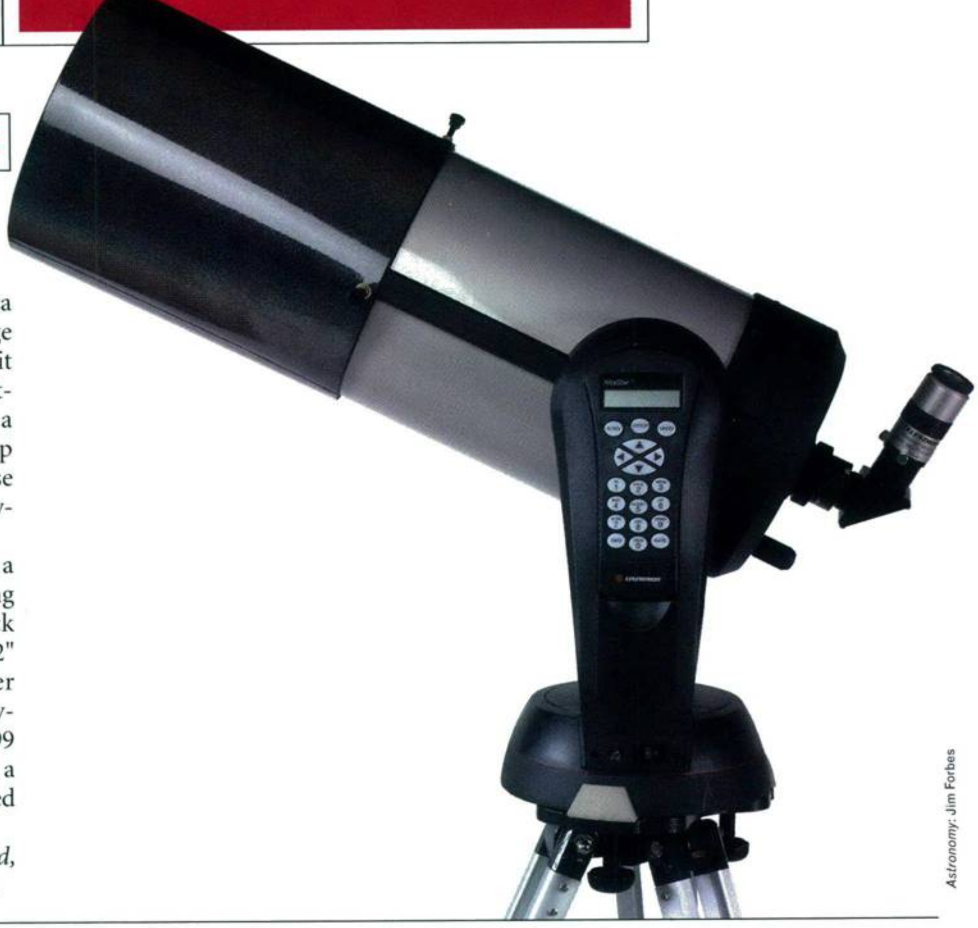
Far left: The Saturn Nebula (NGC 7009) imaged with the 16-inch SCT at f/10 and LRGB exposures of 35, 10, 10, and 20 minutes.

Adam Block, NOAO/AURA/NSF

Left: Barnard's Galaxy (NGC 6822) shot with the 16-inch SCT at f/6.3 and LRGB exposures of 30, 14, 14, and 28 minutes.

Bob Sackett and Adam Block, NOAO/AURA/NSF

PRODUCTS



Astronomy: Jim Forbes

AstroZap Dew Shields

For those plagued by damp nights of observing — unavoidable during the summer months of North America — AstroZap offers a surprisingly large line of flexible dew shields made to fit many telescopes. Constructed of lightweight ABS plastic and coated with a special starfield finish that will dress up any scope for a special occasion, these shields will enable you to keep on observing through many a damp night.

These high-quality products include a felt-lined interior to prevent scattering of light, sewn Velcro strips for quick wrapping around the scope's rim, a 2" rubber trim, and easy storage either rolled or flat. Each has a 30-day money-back guarantee. Prices range from $19.99 for binocular dew shields to $88.50 for a shield to fit a 14-inch SCT; higher-priced aluminum shields are also available.

AstroZap, P. O. Box 502, Lakewood, OH 44107; website: www.astrozap.com.

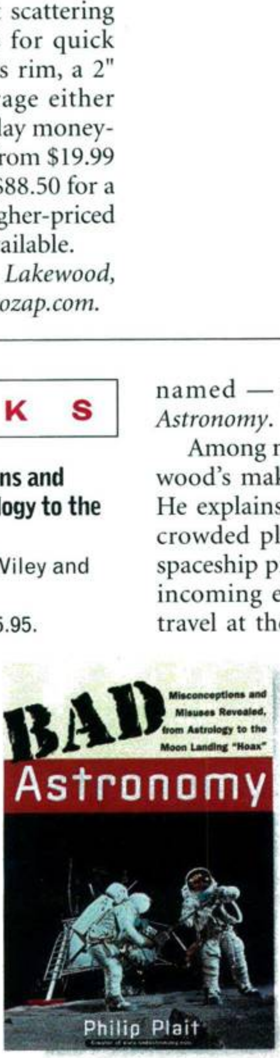
BOOKS

Bad Astronomy: Misconceptions and Misuses Revealed, from Astrology to the Moon Landing "Hoax"

Philip Plait, 277 pages, John Wiley and Sons, New York, 2002; ISBN 0–471–40976–6; paperback, $15.95.

Bad Astronomy . . . is good astronomy.

After Philip Plait earned his doctorate in astronomy, he became increasingly frustrated by media misinformation. For example, why do newscasters keep referring to Hubble's "giant lens" when that telescope has a mirror? Instead of turning to psychotherapy, Plait channeled his exasperation into the creation of a website, www.badastronomy.com. When the popular site accrued more than a million hits, Plait assembled the most comical, egregious, sinister, stupid, and common astronomy blunders into an entertaining new book named — not surprisingly — *Bad Astronomy*.


BAD Astronomy
Misconceptions and Misuses Revealed, from Astrology to the Moon Landing "Hoax"
Philip Plait

Among my favorite subjects is Hollywood's make-believe version of space. He explains why asteroid belts are not crowded places, and why even skilled spaceship pilots couldn't actually dodge incoming enemy lasers. "Laser beams travel at the speed of light, so there is literally no way to tell that one is headed your way."

Other juicy chapters target topics like UFOs, astrology, eggs balancing on the equinox, companies that claim to name stars after you, and the supposed Apollo hoax (some books and a TV documentary maintained that the moon missions were staged). Plait competently and enjoyably discredits such fallacies and scams.

But the book's title itself — *Bad Astronomy* — sets up its author for potential slings and arrows from astro-savvy "gotcha" critics. Woe to Plait if his paperback contains goof-ups of its own.

Well, first editions always have errors, but Plait's are happily few and generally minor. He says, for example, that passengers in a fast-turning car are pushed sideways by the centripetal effect when he means centrifugal, and he offers an incorrect explanation of why airplanes tilt their wings to turn.

Of greater concern is Plait's choice of some subjects. He devotes a chapter to debunk the idea that you can see stars in the daytime by looking up a chimney — but this misconception belongs to our parents' generation. Few under 40 have ever heard of that notion, therefore the need for its debunking is questionable. Such chapters may still serve historical purpose, however. In any case, whether a particular topic is personally appealing or just okay, *Bad Astronomy*'s agenda stays on the mark: Phil Plait is one of the true knights in the noble crusade against astro-babble.

Since backyard starwatchers often recognize astrofrauds, and since astrologers routinely ignore rational reasoning (few would deliberately subject themselves to Plait's relentless logic) — who is *Bad Astronomy* aimed to reach? Fortunately for the author, the book should appeal to a wide range of skeptics including amateur astronomers, especially beginners, who want to avoid common (and not so common) misconceptions.

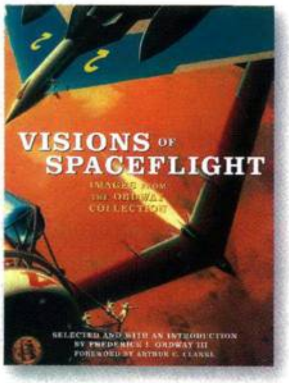
Bad Astronomy is also an absolute "must" for public libraries, and for educators trying to help their students lift the persistent fog of pseudoscience. For the rest of us, Plait sprinkles the text with interesting factoids: "The moon appears the size of a dime located seven feet away." He also provides continuous chuckles about how our beloved and familiar celestial objects can come out of the mass media so humorously twisted and just plain wrong. This lively book — which belongs in the home library of every skeptical thinker — convincingly proves that a myth is as good as a smile. — *Bob Berman writes the Strange Universe column for* Astronomy.

Visions of Spaceflight: Images from the Ordway Collection

Frederick I. Ordway III, 176 pages, Four Walls Eight Windows, New York; ISBN 1-568-58181-5; hardcover, $49.95.

Long before manned voyages to the moon and the first artificial satellites, Frederick Ordway was fascinated by space travel. For many generations, dreams of leaving Earth were relegated to a few illustrated books and the imagination. With 20th-century technology, these visions were translated onto the covers of science fiction magazines, Hollywood movies, and eventually, reality — for the most part.

In *Visions of Spaceflight*, Ordway shares some of the finest images of space travel from his personal world-class collection of books, prints, photographs, and paintings he has amassed over a lifetime. The truly delightful artwork of astronautics and rocketry, both real and imagined, span more than 500 years to the eve of the space age; many are reproduced from original drawings and etchings. This large format volume features hundreds of black-and-white and glossy color photos of fantastic space vehicles of all shapes and sizes cooked up by scientists, dreamers, and true pioneers of spaceflight. Ordway himself says that these pieces "helped inspire and pave the way to the space triumphs of the later half of the 20th century."


VISIONS OF SPACEFLIGHT
IMAGES FROM THE ORDWAY COLLECTION
SELECTED AND WITH AN INTRODUCTION BY FREDERICK I. ORDWAY III
FOREWORD BY ARTHUR C. CLARKE

Arthur C. Clarke provides a brief foreword, while Ordway recounts his amazing collecting quest in an introductory chapter. Here readers learn that the author's most prized acquisition is an early 17th-century British semiscientific discourse on the probability of the moon being habitable.

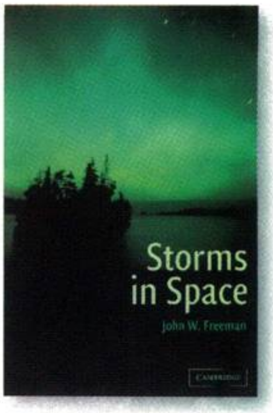
Ordway became enchanted with space travel at a young age, collecting space fiction books and pulp magazines of the 1930s and 1940s. He credits well-known space industry pioneers like Willy Ley and Frederick Durant as major influences on his career and passion. As an award-winning author, Ordway collaborated with the legendary rocket scientist Werner von Braun on several rocketry books during the early days of the U.S. space program.

From our perspective, most of the paintings are considered dated; however, the winged chariots and hot-air balloons gliding up to the heavens provide a wonderful glimpse into the romantic fantasies of visionaries of centuries past. A section devoted to the artwork featured in *Collier's* magazine during the 1950s rules as a nostalgic highlight. This series on the conquest of space anticipated technological achievements of space science and influenced young minds to pursue careers in space.

Anyone interested in antiquarian aerospace art will thoroughly enjoy this one-of-a-kind anthology. Although our scientific knowledge has overtaken most of the quaint visions, readers are provided a fascinating glimpse at the evolution of the idea of space travel through the ages. — *Andrew S. Fazekas*

Storms in Space

John W. Freeman, 192 pages, Cambridge University Press, New York, 2001; ISBN 0521660386; hardcover, $28.



During my 24 years in weather forecasting and television weathercasting, many profound changes have occurred to make forecasting Earth's weather more accurate. Space weather forecasters, by contrast, are only beginning their dreams of forecasting solar radiation and its effect on our climate accurately. After reading this engaging book I've come to have great empathy for these pioneering spirits.

John Freeman takes an exceptional approach to explaining a very technical subject by using an analogy between forecasting solar particle streams and forecasting Earth weather. While humans can easily see Earth's weather on a daily basis, the bombardment of solar energy into Earth's atmosphere goes unnoticed by nearly everyone. Only after news articles chronicling lost satellites or disruptions of communications can we appreciate the value of knowing when normal incoming radiation creates a devastating storm.

The author of *Storms in Space* smoothly accomplishes descriptions of the effects of space weather by relating stories of pilots losing their GPS navigation, NORAD losing track of 75 satellites orbiting Earth, weather satellites losing hours of data, and cable television outages through broken uplinks. He shows the danger of particle bombardments to astronauts in and away from their space shuttles or stations.

Freeman also describes how weather forecasters have come a long way in the past few decades, aided by thousands of observational data sources, satellite technologies, and supercomputer modeling. Imagine a space storm forecaster attempting to create a prediction with only a few sensors in space, no visible pictures of the incoming "storm" of protons and electrons, and no computer models for future calculations. Freeman intelligently explains not only the importance of this information to our lives, but also where the science community is in terms of space weather forecasting.

This work manages to employ easy illustrations and examples, avoiding most complex mathematics. While average readers will enjoy this book, a solid foundation in science will make it more enjoyable. From this book, I gained a new understanding of the upper atmosphere, especially the magnetosphere, ionosphere, and aurorae. I also gained a curiosity for the future of space forecasting, something that we will all hear more about in the coming years. — *John Malan is a veteran meteorologist with WTMJ TV, Milwaukee's NBC affiliate.*

The Webweaver Picks

by Richard J. Bartlett

Twenty-five years ago there was no such thing as the Internet. When Jon Lomberg became the chief astronomical artist for Carl Sagan's *Cosmos* television series, Lomberg relied on contacts to find the people to bring Sagan's vision to life. Today he could go online to find the artists he needs.

Many artists, including some who worked on *Cosmos*, have their own websites. Don Davis's site can be found at www.donaldedavis.com. You can view samples of his work online, which also includes dinosaurs, atmospheric photography, and models. His models for *Cosmos* and other PBS television series appear on his site.

Lynette Cook
Space

Rick Sternbach's site can be found at www.ricksternbach.com. Shortly after completing *Cosmos*, he began working on *Star Trek: The Motion Picture*. Since then he's been involved with the different incarnations of the television series and is currently working on the new movie.

Many artists were featured in the book Sagan wrote to accompany his series. Among them, David A. Hardy is renowned. He has produced work for many other publications, television series and books – including a few of his own. Take a look at www.hardyart.demon.co.uk to find out more.

Don Dixon, a freelance writer and illustrator since 1972, has painted the covers of more than 60 books, and he's currently the art director of the Griffith Observatory in Los Angeles. His site can be found at www.cosmographica.com and contains nearly 400 images plus great movie clips.

Glass Nebula
Paintings
Technique
Biography
The Reverse Glass Art of Joy Day

JOE BERGERON

Daniel D. Durda wasn't old enough to work on *Cosmos*, but he was certainly influenced by it. An astronaut applicant, he's been painting since 1994 and is currently a scientist at the Southwest Research Institute in Boulder, Colorado. His work has appeared in *The Planetary Report* as well as *Astronomy* magazine. Go to www.boulder.swri.edu/~durda to see his work.

An artist well-known to the pages of this magazine, Lynette Cook works with a number of different materials, from acrylics to watercolors, and is best known for her depictions of extrasolar planetary systems. Cook also creates botanical, historical, and technical paintings. Her site at extrasolar.spaceart.org/ showcases her work.

Space-art.co.uk
by Mark A. Garlick

Joy Day uses the unusual medium of glass to produce her paintings. Perhaps not surprisingly, her site is called Glass Nebula and can be found at http://www.glassnebula.com. Originally a costume designer in Portland, Oregon, Day works full time on her astronomical and fantasy art.

Joe Bergeron, an amateur astronomer in California, who describes himself as a "starman, dharma bum, and perpetually puzzled ponderer of the mysteries of life," also produces science fiction art and has been working on his own children's book. Find his work online at homepage.mac.com/joebergeron.

Mark A. Garlick from Brighton, England is also looking to get published. A full-time writer, illustrator, and artist, he's had his work published in many scientific journals and magazines, including *Astronomy*. Producing work with his computer, Garlick's art covers many areas, from traditional astronomical art to surrealism. His site can be found at www.space-art.co.uk.

Similarly, Gary Tonge uses computers to create the artwork featured on his website (visionafar.spaceart.org). Many of his images are quite beautiful and detailed; some have a spiritual influence.

VA
VISION AFAR

B. E. Johnson's engineering background gives him a different view on the universe. Spacecraft star in the paintings on his website (imperialearth.com). Perhaps not surprisingly, he's worked with NASA and created the image for JPL's Stardust spacecraft.

All of Björn Jónsson's images are created entirely with a computer. He specializes in views of the solar system. On his site at www.mmedia.is/~bj/ you can find images, animations and links to download spacecraft models for use with the POV-Ray software.

If Jon Lomberg needed to contact artists today, he obviously wouldn't have to look far. He could visit the fine website of the International Association of Astronomical Artists, perhaps the richest source of variety of all the sites. It's at www.iaaa.org.

Jon Lomberg doesn't have his own site but you can view his work online by going to the Space Media store at www.spacemedia.com.

Visit Richard's StarLore website at http://www.starlore.net.

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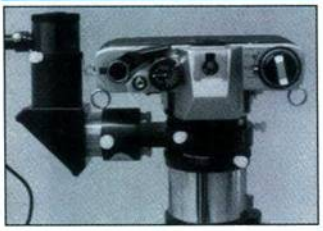

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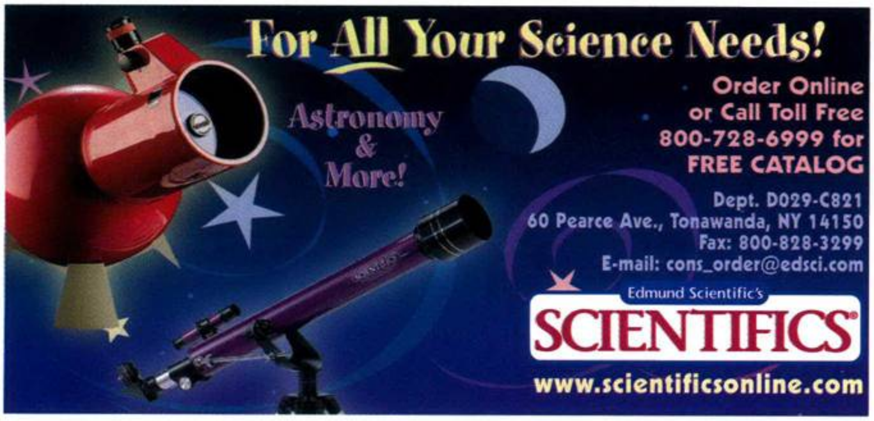

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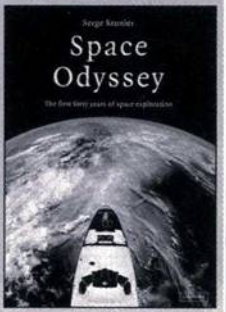

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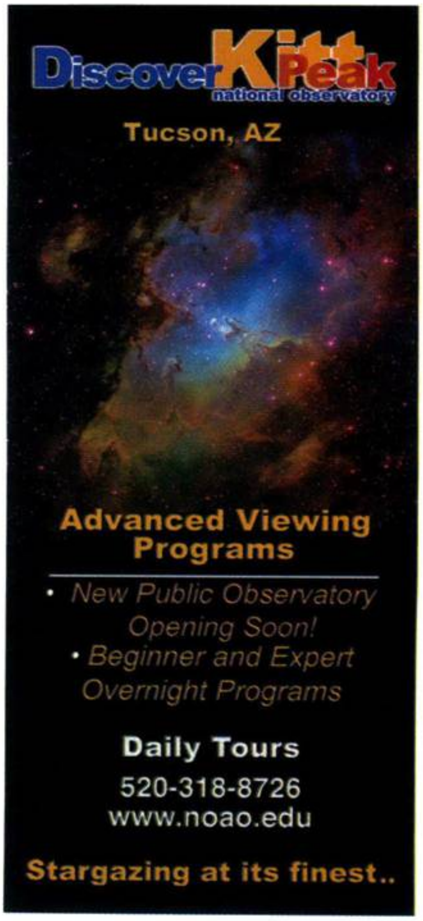

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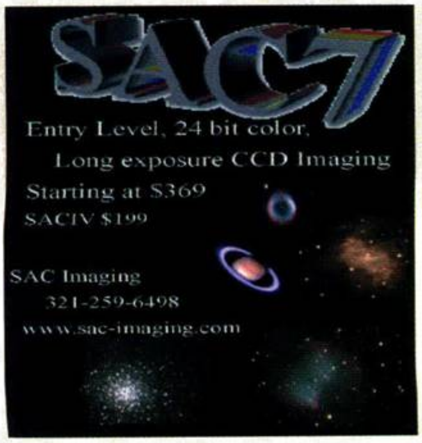

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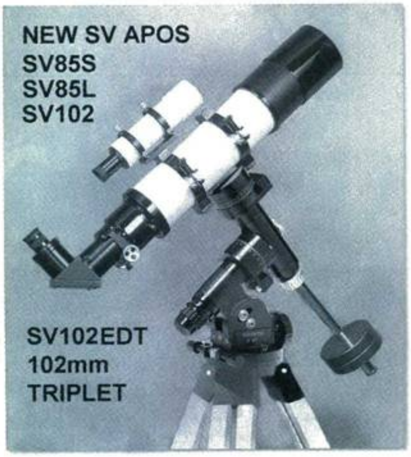

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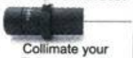

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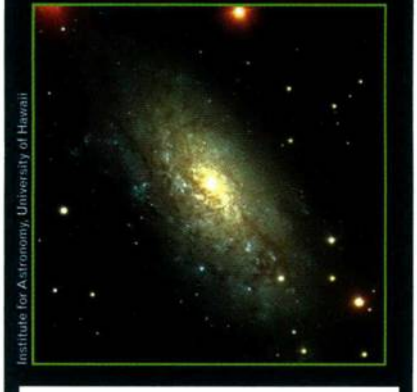

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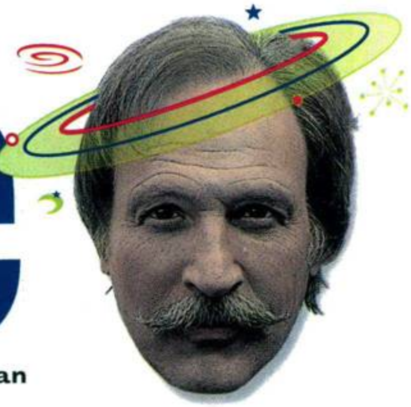

by Bob Berman

Bad Moon Rising

Each full moon has its own name. Actually, several of them — take your pick. A few centuries back, American colonists and native-American tribes called the year's various full moons Rose moon, Milk moon, Sap moon, Thunder moon, and so on. Though out of use for generations, some almanacs still list them, and if you want to get attention at your next club meeting, try yelling, "Hey, check out this milk-thistle moon!"

Only two moon names have survived — Hunter's and Harvest — and just the latter remains popular enough to get media attention. So no dispute, this month's Harvest moon on September 21 is the year's most famous.

Threaten somebody with a tax audit unless they can tell you what makes the Harvest moon special and they still couldn't do it. The usual guesses are: It's more amber or red than other moons. Or maybe it's bigger. Or perhaps lower, or higher. Or closer?

All wrong. It doesn't look special in any way; its *behavior* is different. But the reason this doesn't click is that most folks don't know much about normal moon behavior to start with.

The moon typically rises about 50 minutes later each night. But huge variation occurs throughout the year. In springtime a full moon comes up at sunset and then rises some 80 minutes later the next night, then delays another 1¼ hours the night after that. The effect is dramatic. Just a few nights after the March full moon, it doesn't appear until almost midnight when everyone's asleep. So it effectively vanishes — poof, gone. Spring's full moon has a short shelf life.

This month the opposite is true. The full moon appears at sunset and then for several nights in a row rises just 25 minutes later. (At high latitudes, like Maine, it comes up only 17 minutes later. In Fairbanks it actually rises *earlier* on successive September nights. Talk about weird.)

So you now get a twilight full moon for days on end: It lingers like a boring dinner guest. You can't get rid of it. Folklore explains that the harried farmer, trying to finish early autumn harvesting chores, often runs out of daylight before he is finished. The Harvest moon rescues him night after night to supply welcome illumination. Thus the Harvest moon is an effect, a behavior, a thing the moon does rather than something you could spot with a glance.

By definition, the Harvest moon is the full moon closest to the autumnal equinox. The effect (of rising at nearly the same time for several nights) is stronger if the full moon occurs very near the equinox itself, as it does this year. The effect is also enhanced when the moon's orbital tilt, which wobbles around in an 18.6-year period, is angled the way it is now, with the low part of its slant facing away from the summer sun. Then the moon's nightly reduction in declination becomes unusually pronounced, which exaggerates the narrow angle its orbit makes with the eastern horizon at the time of moonrise.

If you can't picture that, it's no problem. Easier to visualize is how the full moon, Harvest or otherwise, can affect us.

Much folklore and even some current belief revolves around the full moon's supposed powers over human behavior. Nurses say they see a big increase of births at that time. Cops notice more crime. Mental health workers notice more breakdowns. Some almanacs even offer planting and astrological advice based on the moon.

None of those beliefs holds up to scrutiny. Numerous studies checking dates of mental hospital admissions and visits to psychiatric clinics give contradictory but generally negative results. The supposed birthrate link with lunar phase has also been extensively surveyed; a recent examination of 21 studies concluded that births in no way correlate with phases of the moon.

You'll sometimes see literature erroneously claiming that birthrates follow the phases of the moon. These often cite a large 1959 New York City study of 501,000 births, which found a one-percent difference in birthrates between the bright and dark halves of the lunar month, peaking a few days after full moon. Another follow-up study showed a much smaller effect, but this time occurring around the first quarter phase. A very large (six million-birth) European study showed a tiny increase centered at last quarter.

And many other studies show no relationship with any phases at all. An unethical publication citing just the most positive study and ignoring the rest might claim a one-percent effect — but even then it would mean that a maternity-wing nurse could see 101 births one week but 102 births a fortnight later, hardly the sort of thing anyone would be likely to notice.

What happens is that people unconsciously create links between the full moon and events in their lives merely by looking for them. Uneventful hospital weekends, when births happen to be scarce but a full moon blazes overhead, simply get no attention and therefore fail to dispel this common myth.

Yet, paradoxically, investigations during the past 25 years show that the moon does affect Earth in some previously unsuspected ways. A small correlation exists between the full moon and cloudy and rainy weather, possibly caused by either the regular .04° F increase in air temperature at the time of full moon (the cause of which is still debated) or else the known atmospheric "tide," a periodic barometric pulse linked to lunar phase.

Marine creatures and their predators (like gulls and crabbers) exhibit moon-linked behavior because of ocean tides. And average human menstrual cycles so nearly coincide with the moon's 29.5-day synodic phase period that a connection, while not provable, is suspected by many despite that only one other mammal, the opossum, has a similar estrus cycle. This may be a vestigial legacy from our earliest ancestors. Then, venturing out to cruise the woods looking for a mate on bright moonlit nights made more sense than going out in pitch darkness when an animal could end your date early by eating you. Perhaps fertility rhythms evolved to become attuned with the bright, more nocturnally active part of the month.

Another pattern seems linked to the moon: When deprived of outside references, human circadian rhythms — our biological sleep patterns — revert to a 24.9-hour cycle closely matching the average moonrise to moonrise period. This result is both unexplained and intriguing, to say the least.

Finally, a small but statistically measurable increase in earthquake aftershocks occurs at full (and new) moon, no doubt a response to the tidal torques that daily deform the solid Earth by eight inches. These torques are just 1/1000 as strong as the stresses normally present in crustal rock, but could be "the last straw" in a seismic event already teetering on the edge.

So shine on the old superstitions and harvest the new reality — that the full moon still has power.

Owoooo! ◼

Bob Berman, a regular contributor, provides wisdom and wry observations each month in his column "Strange Universe."

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Join the Astronomical Society of the Pacific in the San Francisco Bay area for its 114th annual meeting. The theme of this year's gathering is "Life in the Universe." On Saturday, September 28, Mt. Tamalpais is the location, with renowned astronomer and author David H. Levy discussing "From Stars to Life: Suppose You Had to Design a Universe?" Following Levy's lecture is a free public star party hosted by the San Francisco Amateur Astronomers.

Sunday, September 29 will feature discussions at the University of California at Berkeley led by many prominent astronomers, including Geoff Marcy, Jill Tarter, Chris McKay, Alex Filippenko, and Seth Shostak. The lectures will be followed by a banquet with speaker Timothy Ferris. Admission for the Sunday lecture series is $35 for adults, $30 for ASP members, and $25 for students.

For more information or to register, call the meeting coordinator at (415) 337–1100, ext. 109; website, www.astrosociety.org/events/meeting.html.

Don Carney

High solar activity this month should provide viewers with impressive aurorae.

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Under One Sky
Adler Planetarium and Astronomy Museum, Chicago, Illinois. Exhibit celebrating the influence of astronomy in cultures around the world, spanning thousands of years. For more information, contact (312) 922–STAR; website, www.adlerplanetarium.org.

SEPTEMBER 5–8
Alberta Star Party
Eccles Ranch Observatory, Caroline, Alberta, Canada. Sponsored by the Calgary and Edmonton Centres of the Royal Astronomical Society of Canada. For more information, contact Roland Dechesne at (403) 246–4498; e-mail, rolandd@cnrl.com; website, http://www.syz.com/rasc/.

SEPTEMBER 5–8
Mt. Bachelor Star
Mt. Bachelor Ski Area, near Bend, Oregon. Set in the high desert country at 5,500 feet, this gathering features workshops, demonstrations, lectures, food, and fun. For more information, contact Bob Grossfield at (541) 598–4406; e-mail, info@mbsp.org; website, http://www.mbsp.org/.

SEPTEMBER 6–7
Northern Arizona Star Party
Mingus Mountain, near Prescott Valley, Arizona. For more information, contact the Prescott Astronomy Club, P.O. Box 1114, Mayer, AZ 86333; phone, (928) 632–7355; e-mail, gfreynpo@mindspring.com; website, www.pacorg.net.

SEPTEMBER 6–8
Astronomer's Conjunction
Northfield Mountain Environmental Center, Northfield, Massachusetts. This Astronomer's Conjunction will feature lectures by several distinguished astronomers, including *Astronomy* contributors Bob Berman, Phil Harrington, and Glenn Chaple. For more information, contact Jack Megas, 311 Surrey Road, Springfield, MA 01118; website, http://www.astroconjunction.tripod.com.

SEPTEMBER 6–7
Blackwater Falls Astronomy Weekend
Blackwater Falls State Park, near Davis, West Virginia. Presented by the Kanawha Valley Astronomical Society. For more information, visit its website at http://www.kvas.org/.

SEPTEMBER 6–8
Black Forest Star Party
Cherry Springs State Park, Potter County, Pennsylvania. This event, sponsored by the Central Pennsylvania Observers, is held in Pennsylvania's first official dark-sky park. For more information, visit its website at http://www.bfsp.org/.

SEPTEMBER 6–8
White Sands Star Party
White Sands National Monument, Alamogordo, New Mexico. Hosted by the New Mexico Museum of Space History, White Sands National Monument, and the Alamogordo Astronomy Club, the WSSP is held at one of the nation's premier national parks. For more information, contact the WSSP committee at wssp@zianet.com; website, http://www.zianet.com/wssp/.

SEPTEMBER 7–8
Dark Sky 2002
Swiss Museum of Transport, Lucerne, Switzerland. A symposium to discuss the protection of European dark skies. The weekend will also include a tour of the public observatory of Lucerne. For more information, e-mail info@darksky.ch; website, http://www.darksky.ch/ds2002/.

SEPTEMBER 14

Island Lake Star Party

Island Lake State Recreational Area, Brighton, Michigan. Hosted by the Ford Amateur Astronomy Club. The weekend features prizes, presentations, and a children's observing tour. For more information, contact the FAAC Observing Hotline, (313) 390–5456; e-mail, faac1992@hotmail.com; website, http://www.boonhill.net/faac/.

SEPTEMBER 27–29

ICStars Star Party

Near Warrensburg, Missouri. Held at a private ranch 75 miles east of Kansas City, ICStars will feature guest speaker Mike Reynolds from Cabot Space and Science Center, along with workshops, vendor booths, telescope making, outside family activities, and dark-sky observing. For more information, contact Rob Robinson at rob515@swbell.net; website, http://www.icstars.com/Ranch/starparty/.

SEPTEMBER 29–OCTOBER 6

Okie-Tex 2002

Camp Billy Joe, Kenton, Oklahoma. For more information, contact Mike Weatherby, kmwstar@msn.com; website, http://www.okie-tex.com/.

OCTOBER 3–6

Peach State Star Gaze

White Water Express, Georgia. For more information, visit the Atlanta Astronomy Club's website at http://www.atlantaastronomy.org/main.htm.

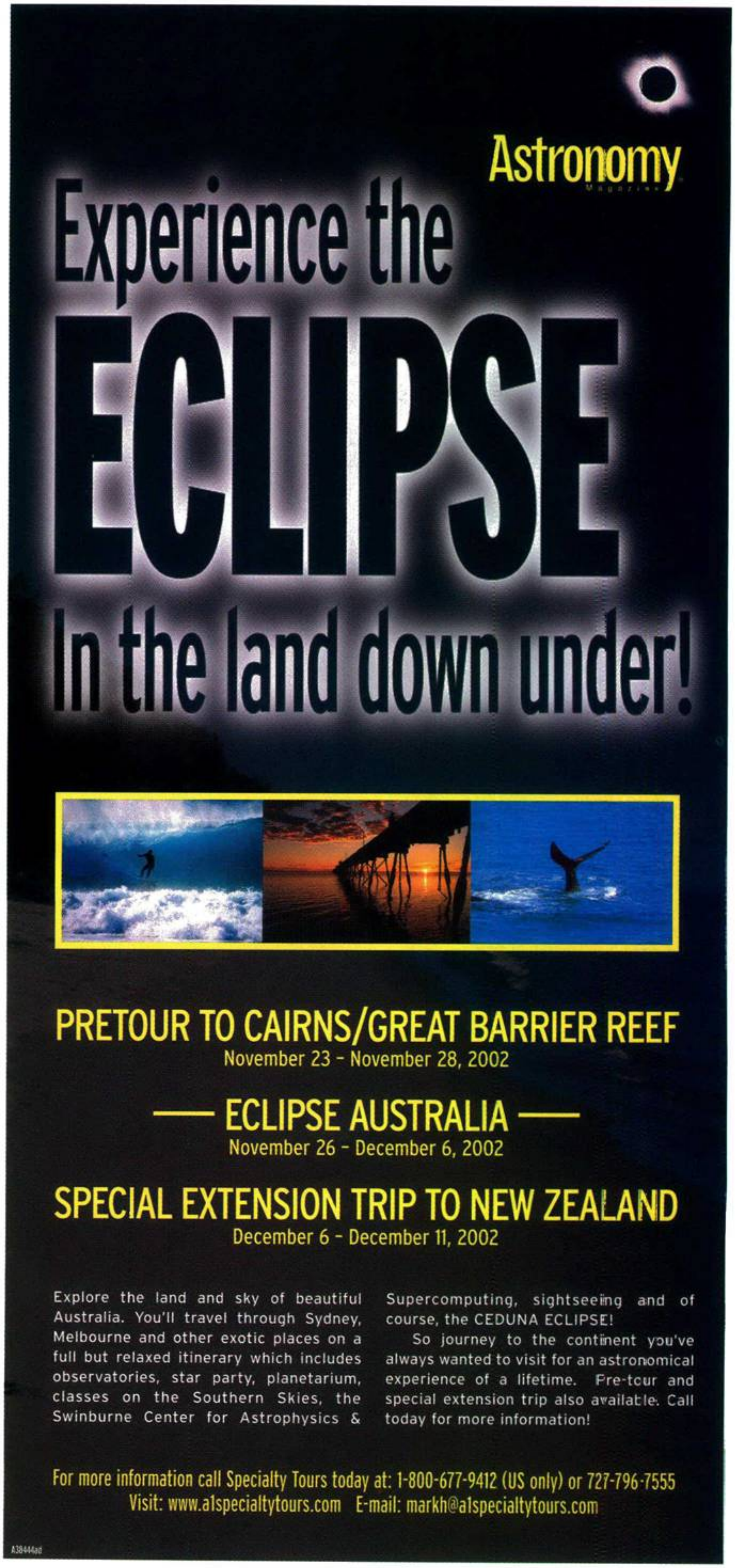
OCTOBER 4–6

Whirlpool Star Party

Doolys Hotel, Birr, Ireland. Hosted by the Shannonside Astronomy Club, the Whirlpool Star Party will feature John Dobson of Dobsonian fame, astrophotographer Jack Newton, Barrie Jones from Open University, Nobel Laureate Antony Hewish, and a number of other speakers. For more information, visit the club's website at http://www.geocities.com/shannonsideac/whirlpol.htm.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.



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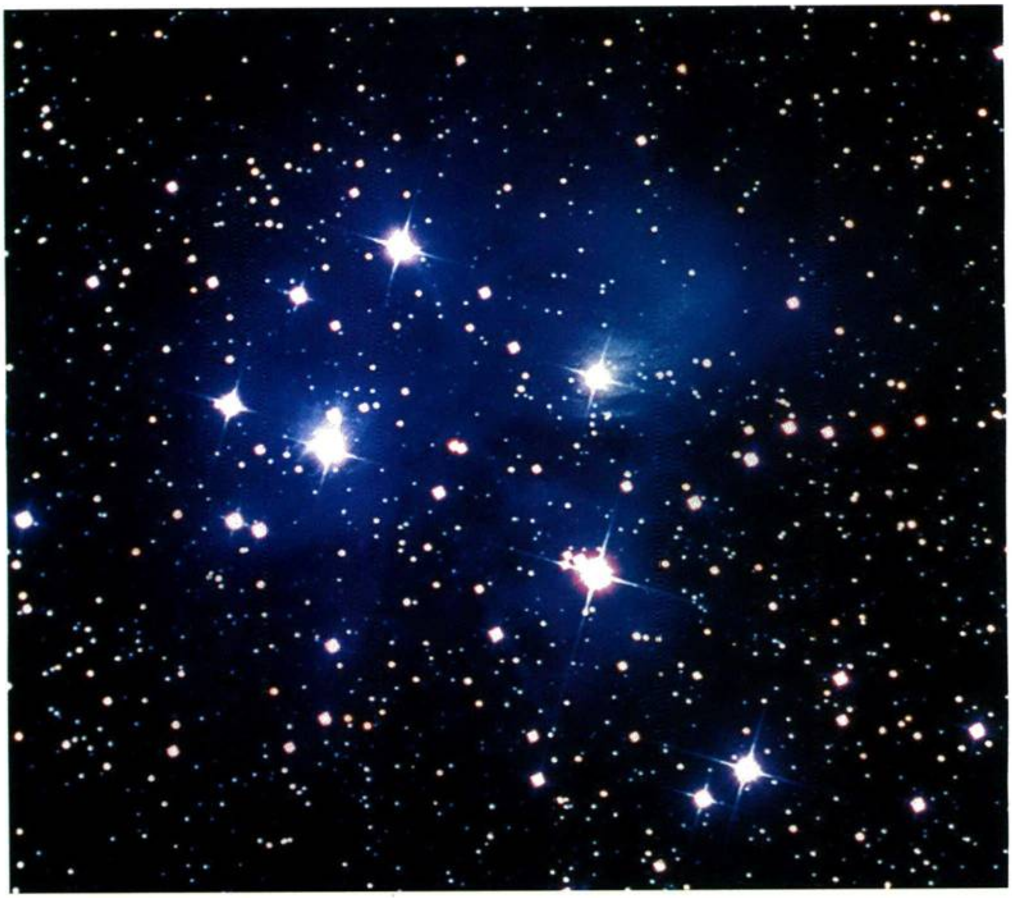
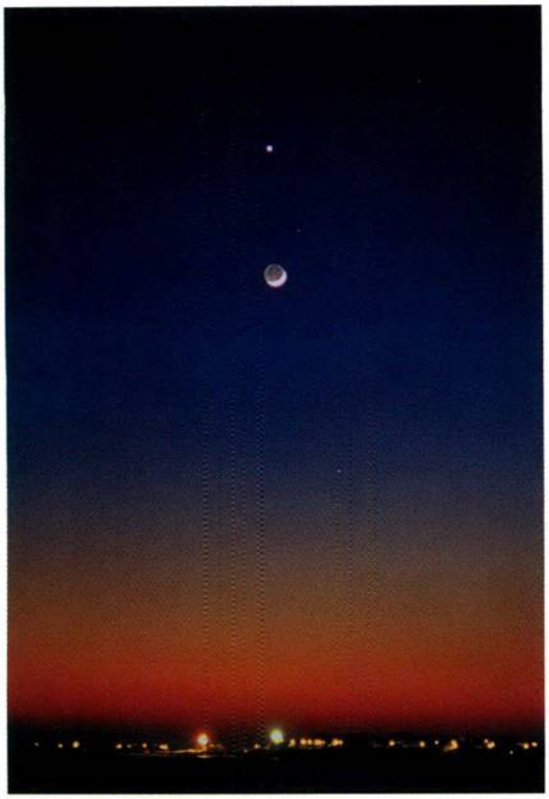
FINDING COSMIC GEMS

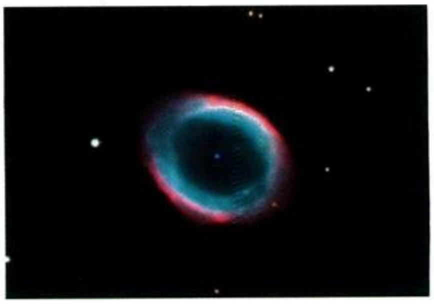
The Great Galaxy Hunt

One of my most successful galaxy hunts happened at the most unlikely of locations — a large trailer park in Lake Isabella, California. We were camping in my parents' beautiful new motor home, and I was anxious to try the newest modifications to my 8-inch reflector. I had taken the time to line the entire tube with black velvet from a fabric store. Although this is not the cheapest way to baffle a tube, I had already lined my small refractor with great results. Lake Isabella is a beautiful, unpopulated area brimming over with old western charm, but the "campground" proved to be a tidy, very well-lit trailer park, just overlooking the lake.

As night fell, I took my cousin Terry outside to view Jupiter, which was low in the west. Jupiter proved to be unspectacular, as was Saturn, so we waited out the sunset. Unfortunately, the darker it got, the more lights went on around us, so we decided to find the darkest spot possible in the campgrounds. Looking every bit like Civil War artillery soldiers, we carried that big black Dob all over the park, looking for the most dimly lit area we could find, but overhead street and motion lights stymied us at every turn. But we didn't give up. Finally, Terry called out to me as he found a seemingly dead streetlight, which we eventually settled under. I installed my 32mm Plössl (also known as "the TV screen," as I call it) into the focuser, and we prepared to search deep into the sky.







Top: M45, the Pleiades

JOHN CHUMACK

(6-inch reflector at f/3.3, Kodak Royal Gold 100 film, 45-minute exposure)

Above: M57, the Ring Nebula

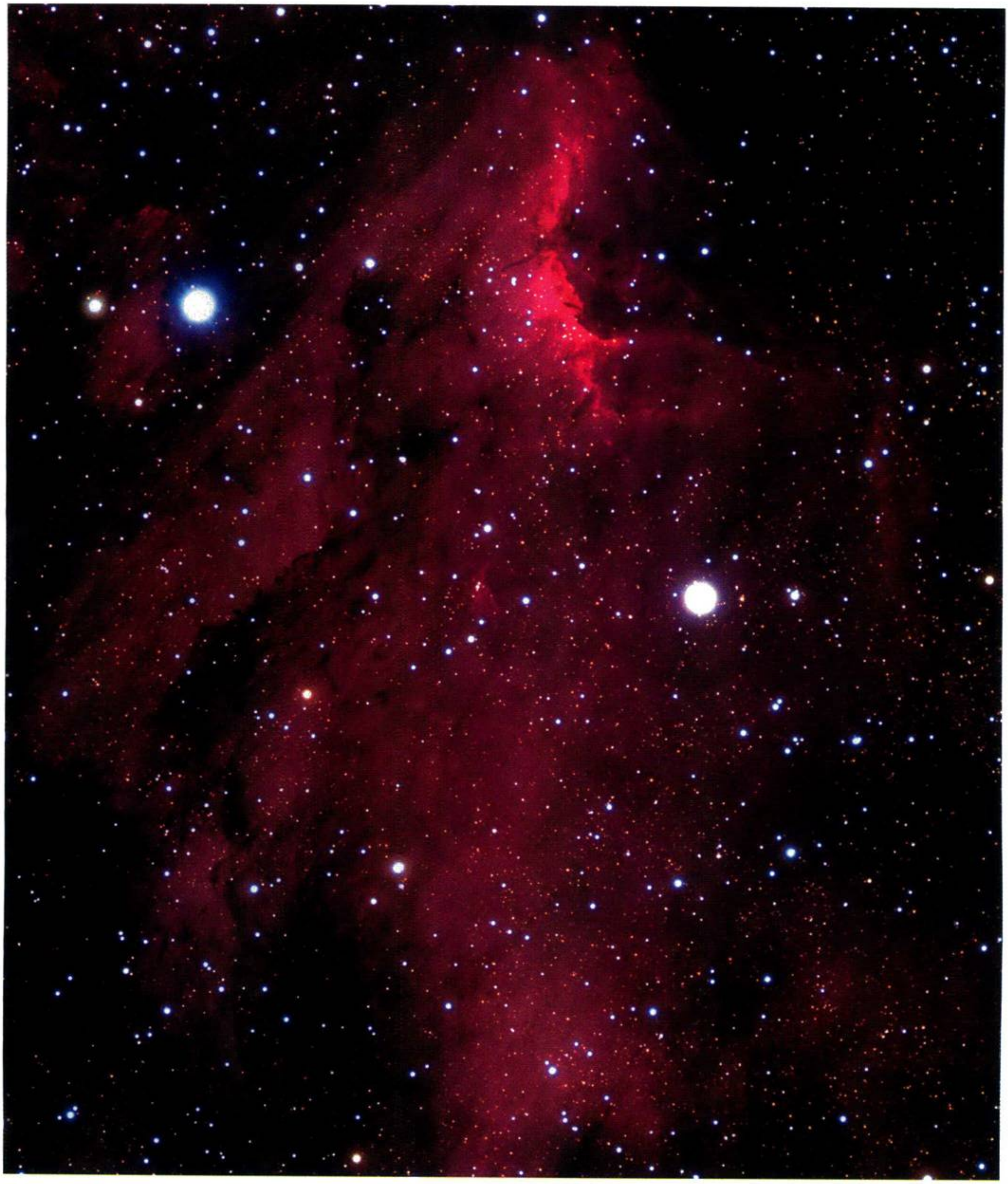
AL KELLY

(32-inch reflector at f/4, Starlight Xpress CCD camera, composite exposure)

Left: Conjunction of Venus, Mars, Saturn, Mercury, and the Moon

GIANNI TUMINO AND MELANIA PLUCHINOTTA

(85mm lens at f/1.8, Kodak 100 film, 6-second exposure taken May 14, 2002)



The Pelican Nebula

CHUCK VAUGHN

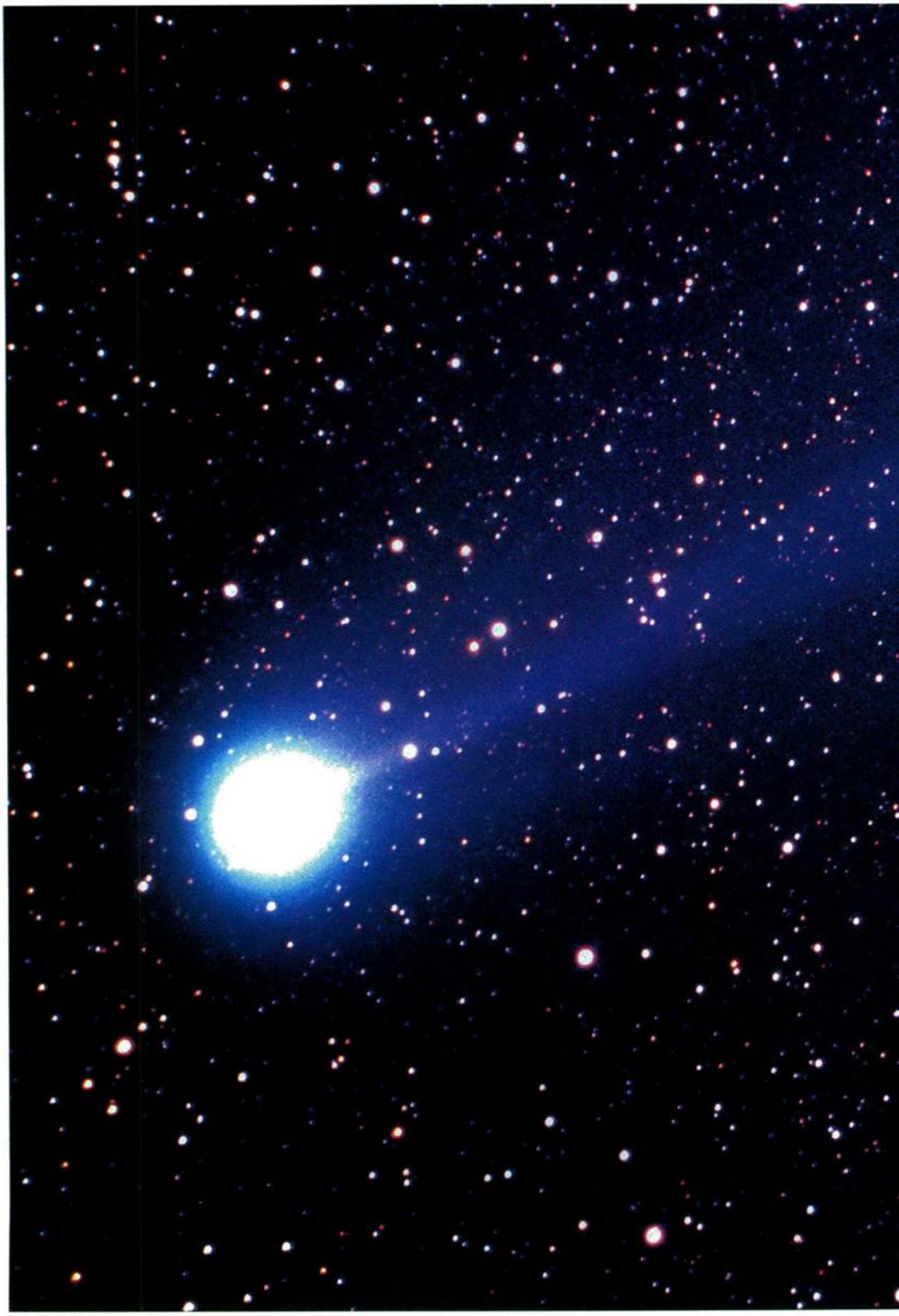
(5-inch refractor at f/8, Kodak Tech Pan film, composite exposure)

Just as I found M104, a blinding flash told me that the streetlight was not truly dead, but just losing its ballast, which would cause it to cycle in 5-minute intervals. Just as I would find an object, we would let out a big groan, as the light would once again fight off its inevitable demise and relight itself. Terry and I continually waited it out, hoping for the light to fail again. After five minutes, we could continue observing. I soon got the hang of it, and we were rewarded with some of the brightest views available in an 8-inch telescope.

Not only were M65 and M66 in Leo extra vivid, but they shared the same 1.3° eyepiece field with NGC 3628; it looked like two vertical eyes with a horizontal smile looking down at us. M81 and M82 were very clear, with M81 showing a hint of its spiral arms. M104, the Sombrero Galaxy, featured definition on both sides of its dust lane, and the Whirlpool showed us great detail and direction.

The highlight of the evening proved to be finding the Owl Nebula, with no filter, and the little galaxy M108 appearing in the same field of view as a thin, bright sliver of light. Terry had never seen a galaxy before (his own 60mm refractor collects dust in the back of a closet) so he was truly impressed. But I was also impressed to find out the potential that can be realized with an 8-inch telescope, a little black velvet, and pristine skies — streetlights or not. ◼

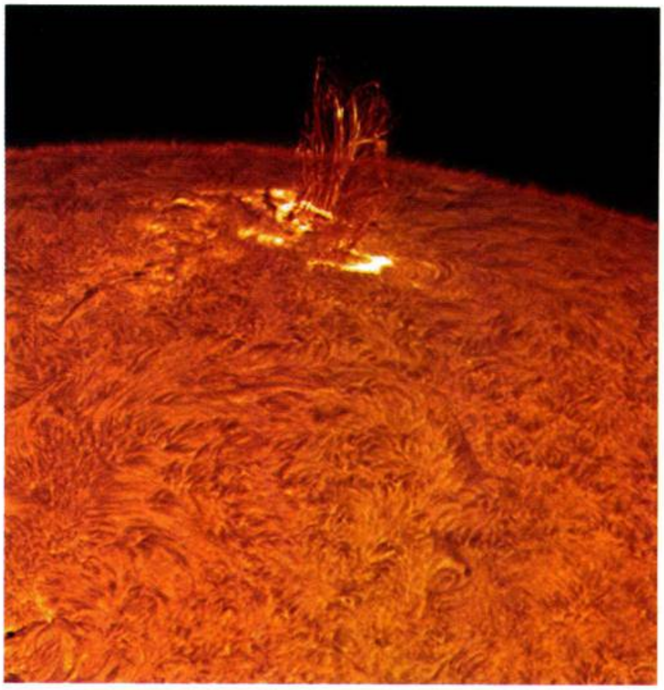
Chris Brown became an astronomy buff eight years ago, after reading past issues of Astronomy *that his wife brought home from a garage sale. He now observes from his home in Irvine, California.*



Comet Ikeya-Zhang

LEE C. COOMBS

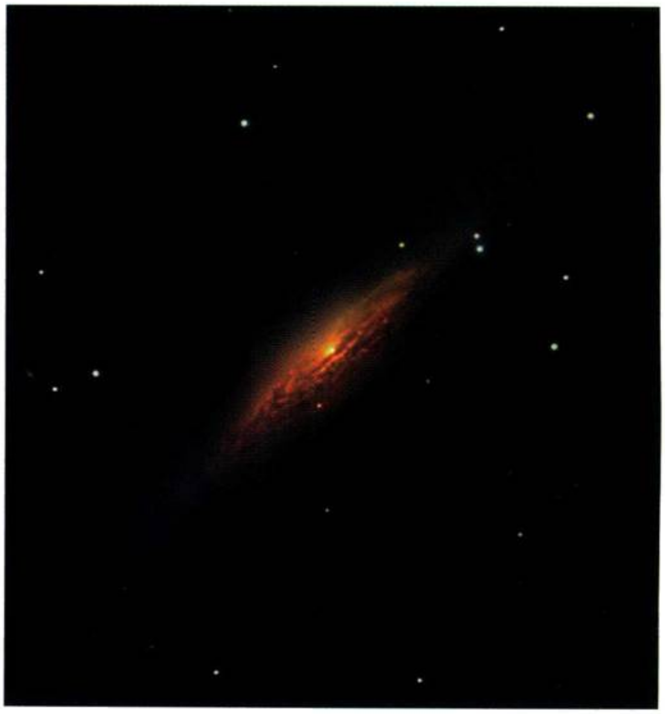
(10-inch reflector at f/5, Ektachrome 200 film, 15-minute exposure taken April 21, 2002)



Solar Flare

JACK NEWTON

(7-inch apochromatic refractor at f/24, Pictor CCD camera, 60-second exposure taken May 27, 2002)

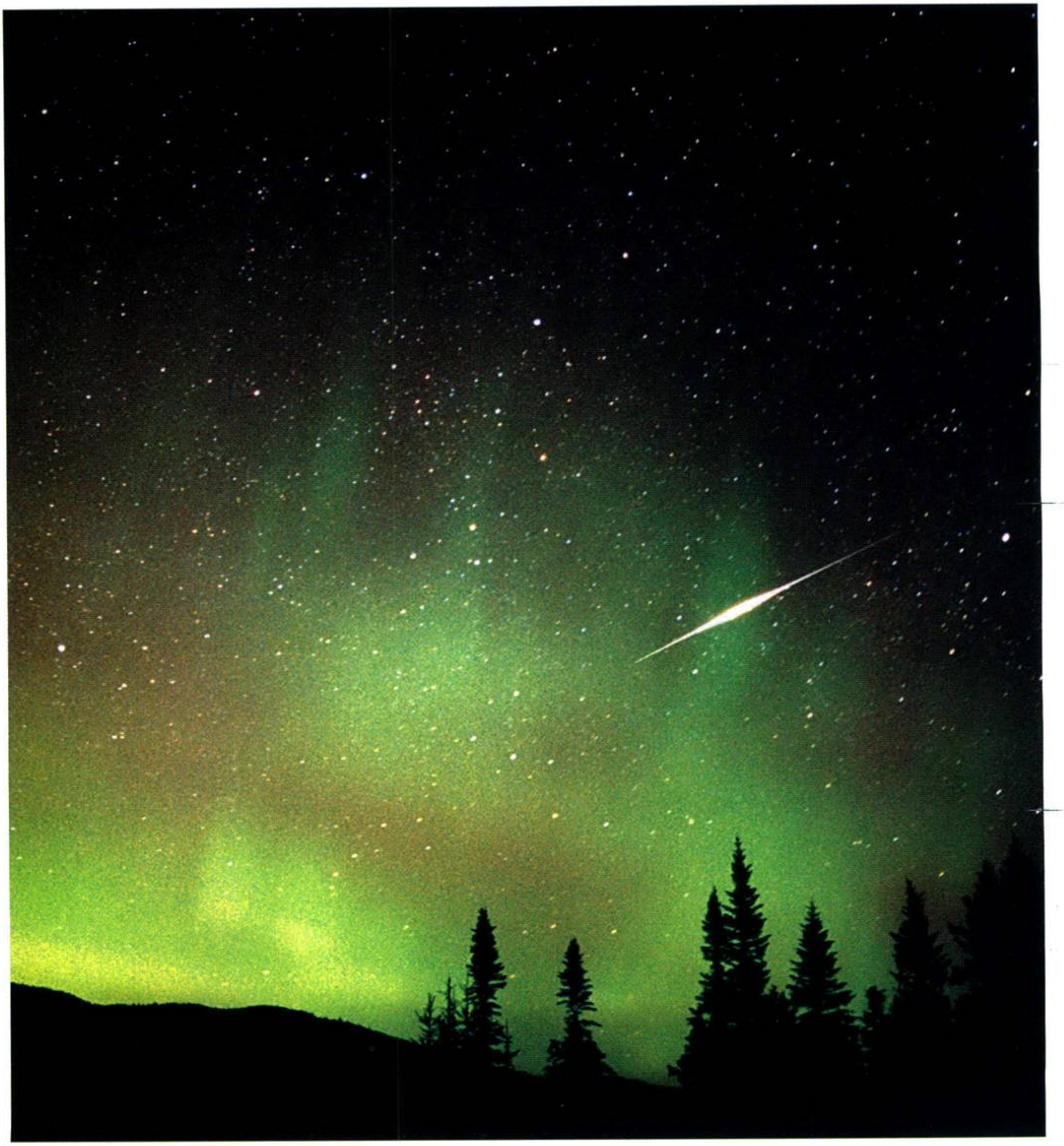


Spiral Galaxy NGC 2683

ROBERT GENDLER

(12.5-inch Ritchey-Chrétien scope, SBIG ST10E CCD camera, composite exposure)

This month's best astrophoto



Aurora with Iridium Flare

DOMINIC CANTIN

(28mm lens at f/2.8, Fuji Superia 800 film, 25-second exposure taken May 11, 2002)

Cantin captured this magnitude -6 iridium flare against a backdrop of aurora in a wildlife reserve north of Québec City, Canada.

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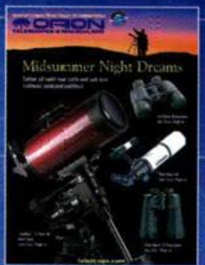
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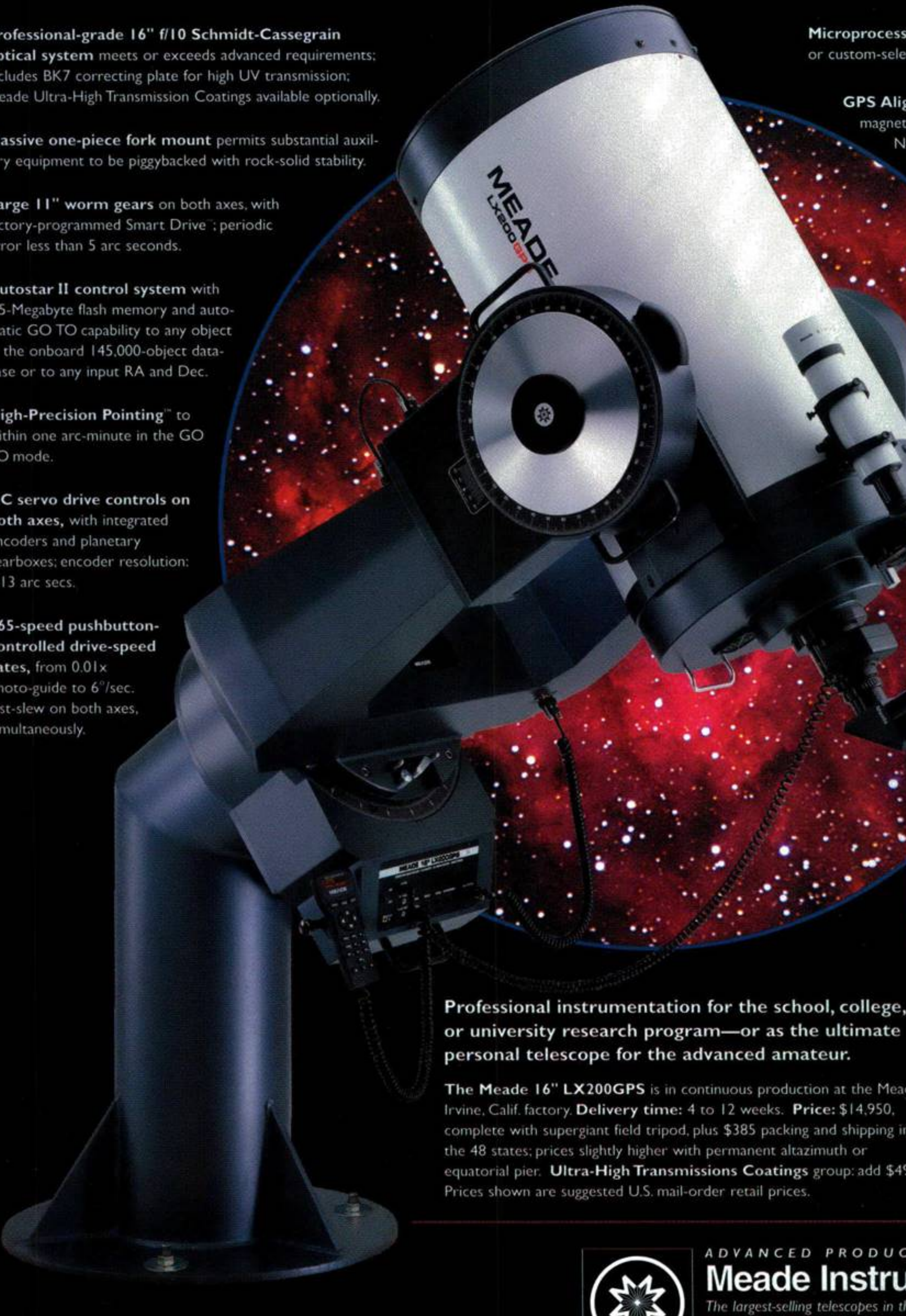

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